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AN APPRAISAL OF THE AIR RESOURCES OF METROPOLITAN BALTIMORE

John M. Brown, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

June 1965

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AN APPRAISAL OF THE AIR RESOURCE OF METROPOLITAN BALTIMORE

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Public Health Service

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AN APPRAISAL OF THE AIR RESOURCE OF METROPOLITAN BALTIMORE

Col. John M. Brown
Maryland State Department of Health

and

F. Donald Maddox
Technical Assistance Branch
Robert A. Taft Sanitary Engineering Center

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Air Pollution

June 1965

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N. Singh Dhillon, Director, Division of Environmental Health

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Howard County Health Department

Palmer F. Wine, Public Health Sanitarian

Maryland State Department of Health

George P. Ferreri, Public Health Engineer

Public Health Service, Division of Air Pollution, Technical Assistance Branch

Jean J. Schueneman, Chief, Technical Assistance Branch

Thomas E. Kreichelt, Assistant Sanitary Engineer

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INTRODUCTION

Early in 1964 the Maryland State Department of Health initiated a meeting of the local health agencies in the Baltimore area to ascertain their interest in air resource management activities.

Representatives from the Anne Arundel, Baltimore, and Howard County Health Departments, the Baltimore City Health Department, the Maryland State Department of Health, and the U.S. Public Health Service met February 7, 1964. At this meeting, a decision to collect and evaluate existing information on air pollution and other facts that relate to the air resource situation was made. This information would in turn be used to determine the need for and the basic design necessary for a comprehensive area-wide study. The comprehensive study designed would have the purpose of providing a foundation of scientifically gathered and analyzed data to support air resource management activities in the Greater Baltimore area.

Work on gathering the information was begun in March 1964. Delays in compiling and evaluating the data prevented the target date for reproduction (August 1) from being achieved. In December, a preliminary report prepared by the State was sent to the U.S. Public Health Service for review and additions. In February 1965, following a second meeting to reascertain the report's purpose, work was continued. In late May 1965, a rough draft of the report was completed.

The report included a discussion of the characteristics of the Baltimore area, reviewed past data on air pollution control and air pollution potential, and made initial recommendations for a comprehensive study and air resource management activities.

SUMMARY

The Baltimore metropolitan area, like all metropolitan areas in the United States, has experienced unprecedented growth in recent years. The increase in the metropolitan population by 1980 is expected to equal one-half of the 1957 population. By 1970, the combined populations of Anne Arundel, Baltimore, and Howard Counties will exceed that of Baltimore City. By 1980 regional employment is expected to increase 38 percent over the 1957 level with increases in industrial development. Such growth will be accompanied by multiplied problems of urban living. Among the continuing problems will be air pollution, which will grow in importance and, if not controlled, will hamper further development of the area.

Industrial emissions add to unsatisfactory levels of pollutants. The individual's automobile is part of one of the largest, most offensive groups of air pollution sources. Even the governments that have the duty to control air pollution are major polluters, allowing or maintaining open burning and the use of outdated equipment and poor fuels in public facilities.

At present, particulate pollutants are a problem. Sulfur dioxide levels have been reduced recently, but remain a potential problem. During summers, Los Angeles-type photochemical smog has appeared as indicated by hydrocarbon and oxidant levels measured. Higher nitrogen oxide and carbon monoxide levels can be expected in the future as a result of the lack of control of nitrogen oxide emissions and the anticipated increase in automobile use.

It is imperative that the increased emissions resulting from metropolitan growth be met with effective control authority and regulations throughout the metropolitan area. This metropolitan area has an advantage over most other urbanized regions in that it has very few political subdivisions. With this advantage, cooperative action can probably be used to establish effective controls throughout the metropolitan area. The need for county action is becoming imperative since most of the area's future growth will occur in the counties rather than in Baltimore.

Baltimore City has the only active control agency among local governments in the metropolitan area. The level of interest and desire to organize effective control authority in the counties is very high in the county health departments. These county health departments also have the support of their political administrations. The County Executives of Baltimore and Anne Arundel Countys and the Mayor of Baltimore have taken steps to establish a cooperative attitude among the upper political administrations on the subject of air pollution. This cooperative attitude already exists among the State, city, and county health departments serving the metropolitan area. A formal cooperative committee is now taking shape, with duties and membership defined by a formal project agreement. This committee's purpose will be to direct an area-wide effort, through pooled resources and knowledge, to determine the scope of the air pollution control program needed to derive optimal use of the area's air resource.

The State Department of Health has an important part to play in the committee's work since much of the data processing and central direction of the committee's administrative functions may be forthcoming from the State. The Federal Government may also be called upon for funds under the provisions of the Clean Air Act and for technical assistance and advice.

Essential elements to be accomplished in designing the needed air resource management program follow:

1. Defining the cleanliness of air desired in various areas.
2. Obtaining knowledge of the ability of the air mass to disperse air pollutants under various conditions.
3. Acquiring ability to predict changes in the dispersion rate of air pollutants.
4. Evaluating emission rates of the various sources in the area, including their locations. These sources include industrial, commercial, residential, and governmental operations.
5. Emphasizing to all levels of government the importance of recognizing that air masses do not follow city or county boundaries and that cooperation across these boundaries is essential.
6. Evaluating present air pollution control programs and laws, and promulgating a uniform system for air resource management, including air pollution control ordinances and activities.

These elements can be accomplished by a comprehensive air resource study directed by the regional committee. Activities would include an air sampling network covering the metropolitan area; an emission inventory; human, plant, and property effects studies; an odor survey; a meteorological study; and the evaluation of all data collected to produce the decisions molding these elements.

After the development of air resource management programs in the counties and the city, the regional committee will still be needed to coordinate county and city activities and maintain liaison on all administrative levels between the health departments. Also, the regional committee will be needed to guide the operation of a metropolitan air monitoring network and an air pollution potential prediction service.

During the conduct of the comprehensive air resource study, the control program of the city must be continued, and control activities of the counties should be an important function of county personnel assigned to the study. Interim functional ordinances, such as one authorizing health department officials to require emission information from persons operating sources of air pollutants, may be needed.

RECOMMENDATIONS

Baltimore City, Baltimore County, Anne Arundel County, Howard County, and the State should work together to develop a comprehensive air resource management program that will continually define the air quality in the metropolitan area, provide the means for making equitable air resource management decisions, and place in effective operation those measures decided upon. This program, directed toward both long-term and short-term benefits for the metropolitan area, consists of the following principal parts:

1. Air Quality Monitoring. Air quality monitoring is essential for the protection of the public health and the operation of an air resource management program. A monitoring program directed toward establishing short-time variations and long-term trends of concentrations of at least the following air pollutants is necessary:

Sulfur dioxide
Settleable particulates
Suspended particulates
Oxidants
Nitrogen oxides
Aldehydes
Hydrocarbons
Carbon monoxide

2. Studies of Effects of Air Pollutants. The effects of air pollutants on human health, comfort, and welfare; the soiling and deterioration of materials caused by air pollutants; and decreased visibility and damage to vegetation attributable to air pollution should be studied on a continuing basis.

3. Air Quality Guides. Recommended air quality guides follow:

   a. Sulfur dioxide concentration (24-hour mean value) shall not exceed 0.1 ppm more than 1 percent of the days during any 100-day period at any sampling site.

   b. Suspended particulate matter concentrations shall not exceed on more than 1 percent of the days during any 100-day period:

      (1) 375 micrograms per cubic meter in industrial areas,
      (2) 275 micrograms per cubic meter in commercial areas,
      (3) 200 micrograms per cubic meter in recreational and residential areas.

   c. Dustfall shall not exceed 20 tons per square mile per month at any location on a yearly average basis (based on twelve, 30-day sampling periods).

These guides apply to any place where people live or where an effect may be objectionable. They refer to time periods related to effects. Measurements of levels are based on sampling periods suitable for the pollutant and measuring method used. The cooperative committee may find that these guides should be revised and others added after the comprehensive study has been completed.

4. Air Pollutant Emission Inventory. Knowledge of the types and quantities of materials emitted to the atmosphere, or otherwise wasted, is good conservation practice and is essential for the operation of an air resource management program, a business, or a community. Those practices and mechanisms that will assure gathering of this knowledge on a continuing basis should be established. The data should be made available to both private and public interests for use in improving air quality control practices and developing new products. Information relating to secret processes of manufacture or product should be protected and kept confidential.
5. Air Pollution Control Organization. Each county should organize, finance, staff, and equip an organization to cope with air pollution problems. The State should provide a better equipped advisory and technical service organization. The City of Baltimore should evaluate its control activities and organization in the light of data from the comprehensive study. The regional committee should coordinate State, city, and county air pollution control actions in the metropolitan area and supervise an air monitoring network and an air pollutant potential prediction service for the area.
6. Planning Organization. Consideration of air quality should be incorporated in planning and zoning decisions and programs. This should include estimation of probable air quality levels that would result from certain decisions and the use of mathematical

atmospheric diffusion models as an aid to making estimates. Land use should be considered in terms of air use, and those uses and locations should be established that will make the best use of the community air resources.

7. Education and Information. A program of education and information should be initiated to inform the people of metropolitan Baltimore of the program objectives and their roles in accomplishing those objectives.

8. Air Pollutant Emission Regulations. Ordinances and/or rules and regulations should be enacted and enforced as needed to reach and maintain ambient air quality goals. The ordinances and rules and regulations should be based on the emission inventory, measured air quality levels, and the air quality goals. Certain conditions may make it necessary for control actions to begin before the completion of the comprehensive study. More power than that generally given by a standard nuisance clause should be given to the county health departments to prevent air pollution. Such ordinance provisions, including those now in effect, should be reevaluated on completion of the comprehensive study in the light of data gathered.

CHARACTERISTICS OF THE REGION

TOPOGRAPHY AND GEOGRAPHY

The Patapsco River (Baltimore Harbor) is the key feature of the region. At Baltimore, the Piedmont Plateau intersects deep, navigable water, and the Baltimore area is a natural focal point for highways, railroads, and rivers serving the region. Metropolitan Baltimore surrounds the deepwater harbor at the head of Chesapeake Bay. Water routes are open for both deepwater and shallow-draft vessels. It is a major area on the Washington-Philadelphia-New York-Boston axis. Unlike other major ports of the Atlantic, Baltimore is located 150 nautical miles from the open ocean and closer to the producing and consuming centers of the inland East and the Midwest than any other major port.

Generally, the land slopes upward to the northwest. Elevations except for a few small hill masses are less than 600 feet. Drainage into the Chesapeake follows fairly deep narrow valleys. Stream flow is usually seasonally intermittent in the upper reaches and tidal at the mouth. The topography offers few access obstacles to the region.

GENERAL LAND USE

Regional land use planning has been in effect for a number of years. Although the planning body is purely advisory, it is influencing local land use applications. There is every expectation that the plans will produce reasonable balance in land use.

A prominent feature of the Baltimore area's land use, Figure 1, is the considerable depth to which the City of Baltimore is set back westward from the shores of the Chesapeake Bay. Far from being a roughly semicircular city abutting a large water body, like Chicago or Milwaukee, Baltimore is like an inland city with a wide ship channel leading to it.

A second land use feature of the region is the detached nature of two major areas, the Anne Arundel County bay shore residential districts and Aberdeen Proving Ground with its residential communities of Bel Air, Aberdeen, and Havre de Grace in Harford County. These are far enough removed from the development around Baltimore to be considered major subareas of the region.

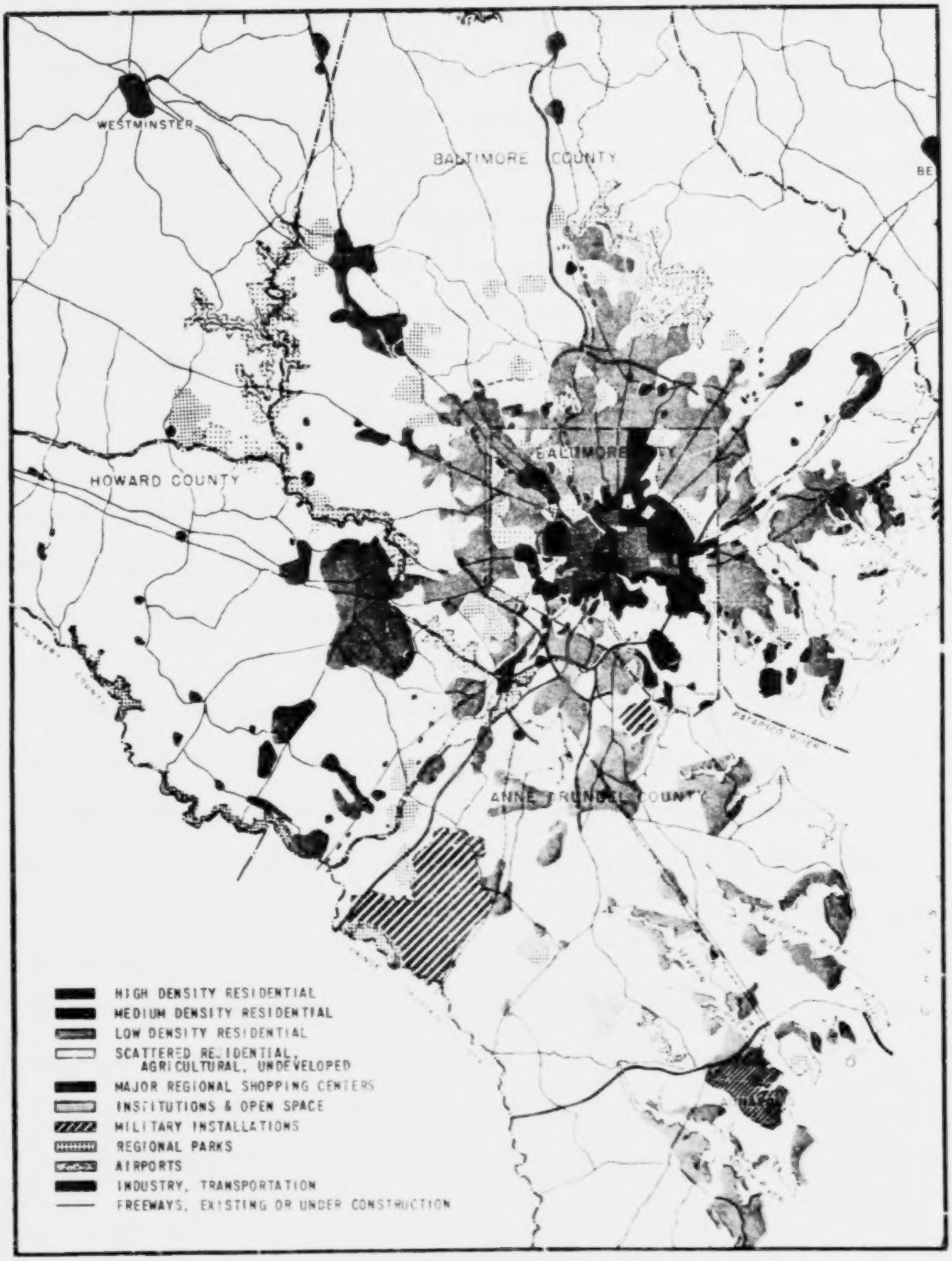

Figure 1. Generalized land use, 1957.

The metropolitan land use pattern approaches concentric ring development with some asymmetries. This pattern begins with a core of commercial and service uses and expands in successive rings of (1) high-density multifamily dwelling and row house residential use; (2) large parks and recreational areas outside the inner city; (3) medium density residential areas of less than 80 persons per acre living in multifamily and row structures; and (4) low density, semidetached and detached residential areas sprinkled with institutions, and public and semipublic facilities. Beyond the rings, and interspersed with the outer two, is the background setting of agriculture or vacant land. Radial spokes emanating from the core strengthen the concentric structure by emphasizing the center. These spokes are prominent because of the mixture of land uses along them, usually resulting from the addition of commercial and industrial uses to the prevailing residential density along major highways or railroads.

The two most prominent asymmetries are the broad reaches of the Patapsco River to the southeast and the fringe or necklace of large industrial areas concentrated on the upper reaches of this water body. These water-edge industries are primarily port oriented and provide much of the primary employment in the region. Distinct from the other major land uses centered around the central business district, these industries lie in an oval pattern around the water, which serves as a focal point.

The influence of transportation is seen, particularly, in the concentration of high intensity uses at the head of navigation where early transshipment took place. This point of concentration was strengthened by the northeast-southwest Atlantic coastal land transportation lines, which pass through it. Outward growth to the northwest where a network of land routes could be developed has always been more dense than that to the southeast where the Patapsco River forms a barrier to free movement. Land development formed a horseshoe around the river; the lower arms of the horseshoe have been limited to scattered growth while the top of the horseshoe has enjoyed more compact growth. Land transportation lines across the water barrier via tunnels (the Baltimore Harbor Tunnel and the proposed Hawkins Point Crossing) have begun and will continue to increase the density and intensity of development throughout the areas southeast of the center.

Commercially, lighter forms of trade appear to be consolidating in shipping centers. These centers appear to have greater influence in the development of residential areas than the industrial activities that provide occupation for the residents. Improved highways and abundant private transportation appear to provide the needed flexibility that permits jobholders to choose residences over a wide radius from their places of business. In consequence, there are presently few areas of high density population outside the first concentric ring. Land use planning is now being directed to emphasize this concentric ring development, Figure 2.

ECONOMY

Dominant characteristics of metropolitan Baltimore's past development and its peak periods can be identified as: agricultural commerce, 1815; industrial center, 1860; enlarged city and broadened industrial base, 1919; and automobile-oriented region, 1945 to the present.

Originally through this port flowed raw materials, principally agricultural products, from Maryland and parts of Pennsylvania and Virginia

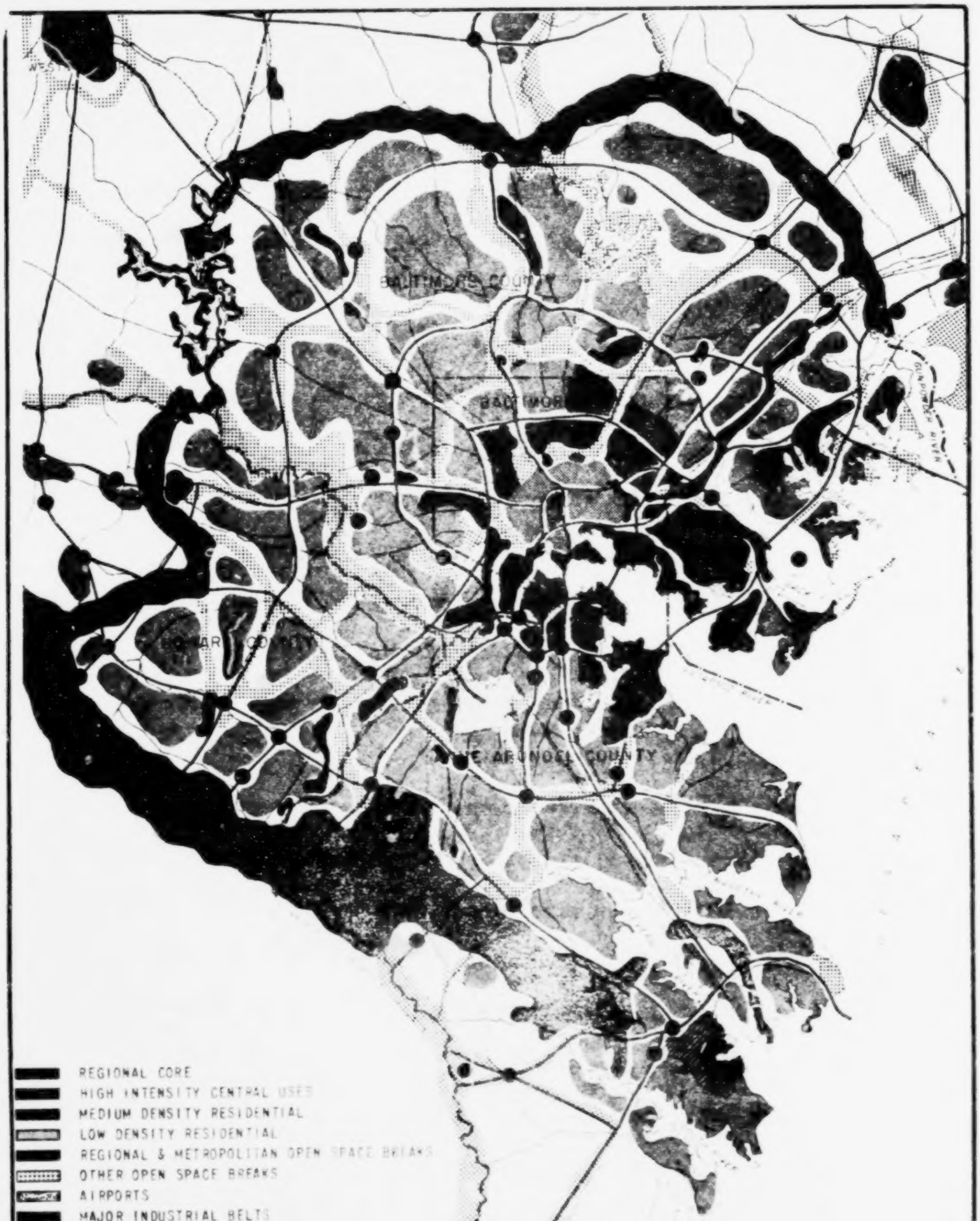

Figure 2. Generalized land use plan, 1980.

in trade for finished products from seaborne traffic. By 1860, Baltimore itself had become a notable source of manufactured goods. It exported finished products to the world in increasing quantities, and although the commerce in basic agricultural products continued at a high level, its relative proportion declined. Today widely diversified industry is the greatest source of the Baltimore area's wealth, income, and economic stability.

Raw materials are generally imported from other sources and turned into finished products for distribution to other markets. For this reason, heavy industries are most often in the immediate vicinity of deepwater facilities at which bulk items can be handled either directly to the consumer, as is ore to the steel plant, or transshipped to the user. Among these heavy port industries are the Nation's largest steel mill, two large copper refineries, one of the largest sulfuric acid plants, gypsum product plants, oil refineries, fertilizer plants, chemical plants, and a shipbuilding and repair industry.

Industry is not confined to the harbor, however. Broadly diversified industries not primarily dependent on bulk raw materials have been located and are locating on sites accessible to rail and arterial highways that radiate from the port facilities. Some plants have taken advantage of land areas newly released to industrial uses for which water-borne facilities are planned.

Research and development projects, both public and private, are substantial. These involve many phases of science and engineering. Several are in health fields, such as the effects of air pollution on respiratory infections.

Expansion of industry is anticipated, but at a comparatively steady rate.[2] Some possibility of increased heavy industry exists when rezoning of deepwater facilities is accomplished. The greatest growth will, however, probably occur in the lighter industries, such as electronics, assembly, and fabrication of items. Figure 3 shows the general distribution of industry in the metropolitan area.[1]

Baltimore's commercial community is very important both for its economic influence and its effects on the distribution of residential land use. Over 160 neighborhood and community shipping concentrations have stimulated suburban development around the city. Much of this growth has occurred in the metropolitan counties.

Because of its many advantages as a distribution center, Baltimore has long been one of the principal wholesaling and jobbing markets in the United States. The handling of such trade forms a considerable part of its overall commercial volume (Table 1).[3] Table 1 also shows the small proportion of total product derived from agriculture.

POPULATION

With improved roads, many Baltimore residents have moved to the suburbs. This trend has been temporarily accelerated by Baltimore's ambitious program of urban rehabilitation and improvement. This program necessarily reduces the number of housing units temporarily. As new units replace the old, the Baltimore population is expected to stop decreasing and rise slowly to about 1,000,000 people by the year 2000.

Figure 4 shows the population change from 1920 to 1960 and the projected changes to the year 2000.[4, 5] The trend to suburbs can be seen in the large increases in county populations while the city population remains essentially static.

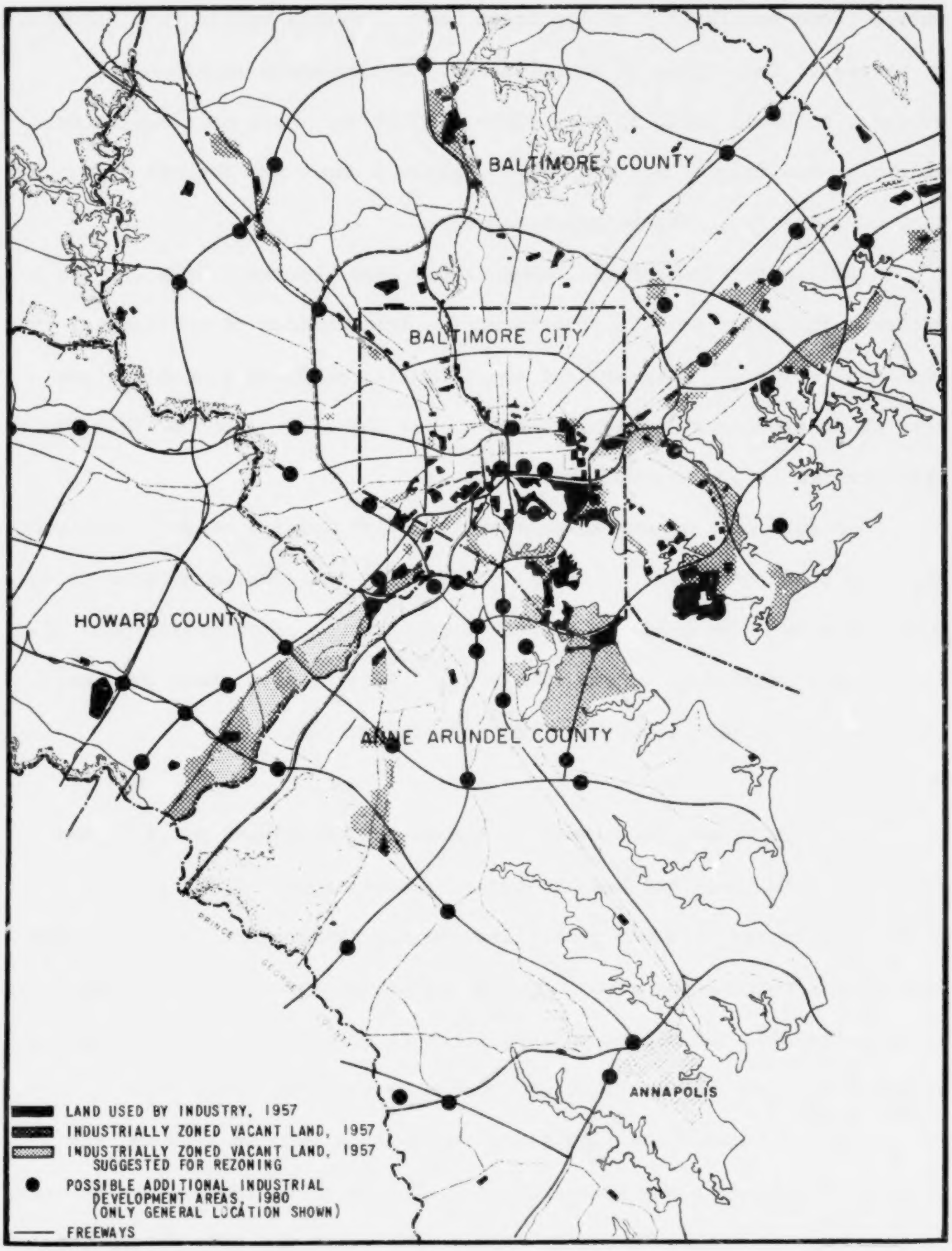
BALTIMORE COUNTY
BALTIMORE CITY
HOWARD COUNTY
ANNE ARUNDEL COUNTY
ANNAPOLIS
PRINCE GEORGE'S COUNTY
LAND USED BY INDUSTRY, 1957
INDUSTRIALLY ZONED VACANT LAND, 1957
INDUSTRIALLY ZONED VACANT LAND, 1957 SUGGESTED FOR REZONING
POSSIBLE ADDITIONAL INDUSTRIAL DEVELOPMENT AREAS, 1980 (ONLY GENERAL LOCATION SHOWN)
FREEWAYS

Figure 3. Industrial land, 1957-1980.

Table 1. COMBINED ECONOMIC EVALUATION OF BALTIMORE, BALTIMORE COUNTY, ANN ARUNDEL COUNTY, AND HOWARD COUNTY[a]

Value added by manufacturing (1959)	$1,980,000,000
Value of farm products sold (1959)	24,000,000
Retail sales (1958)	1,840,000,000
Wholesale sales (1958)	2,667,000,000

[a] Reference 3.

Table 2. EMPLOYMENT IN 1952 AND 1962[a]

Year	City of Baltimore	Anne Arundel County	Baltimore County	Howard County
1952	351,700	10,600	79,800	2,100
1962	325,000	31,900	105,500	4,300

[a] Reference 4.

Table 3. AVERAGE WAGE PER EMPLOYEE, 1952 AND 1962[a]

Year	National average	City of Baltimore	Anne Arundel County	Baltimore County	Howard County
1952	$2,830	$3,170	$2,745	$3,750	$2,570
1962	4,580	4,804	5,017	5,590	4,510

[a] Reference 4.

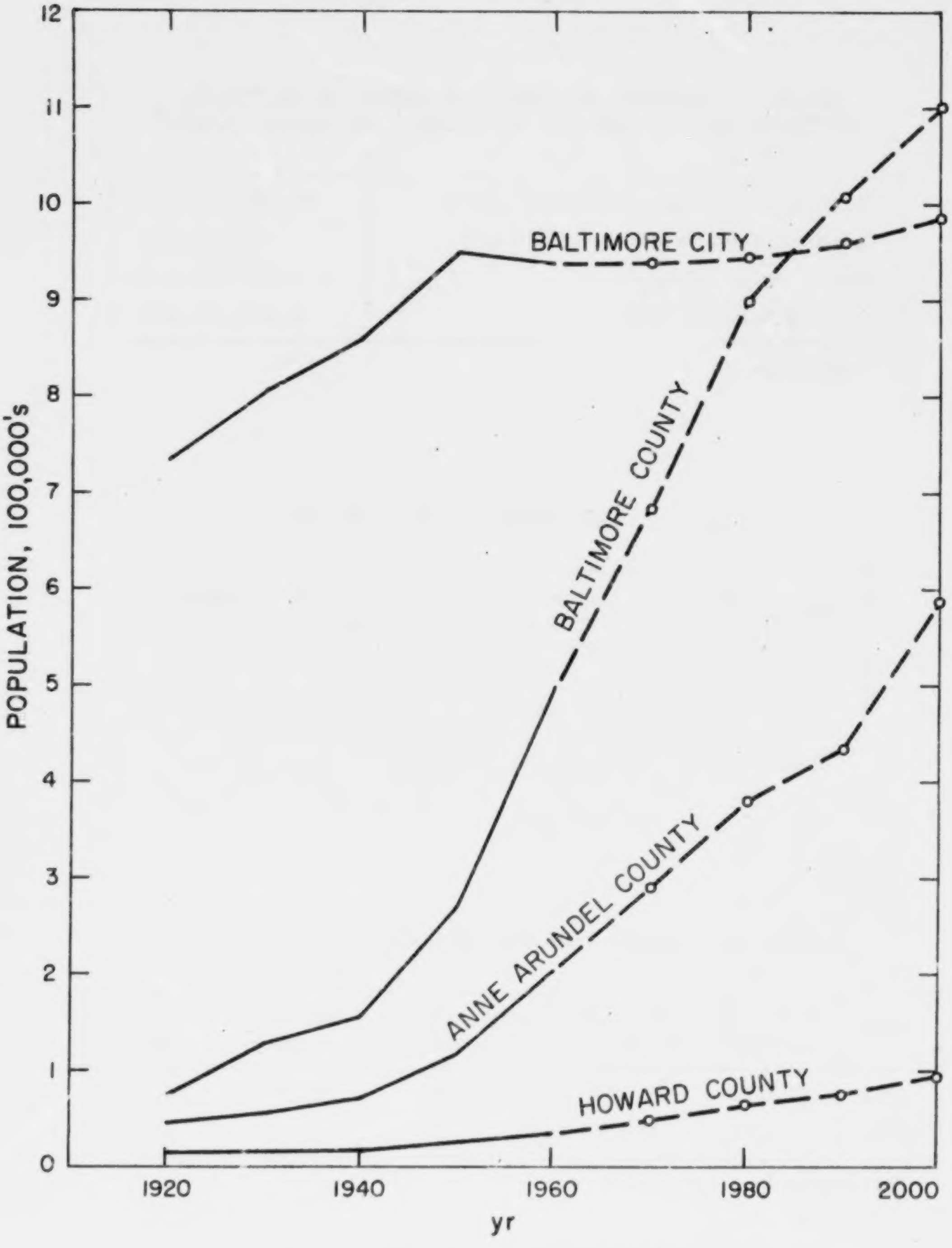

Figure 4. Population trends.

By 1970, the combined population of Baltimore, Anne Arundel, and Howard Countys will exceed that of the City of Baltimore. Figure 5 shows where the population has grown in the past and probably where it will grow in the future.[6] Some growth is expected within the outer limits of the city, but primary growth will occur outside the city limits. In the past, the metropolitan area's population has been concentrated within a 10-mile radius of downtown Baltimore. By 1980, the population density of this area will have increased considerably, and the metropolitan population will have spread to a radius of 15 miles from downtown Baltimore. This growth will bring the urbanized area to the Harford and Carroll County boundaries, and to within 10 miles of Annapolis.

EMPLOYMENT

As in many industrial centers, the amount of employment in the metropolitan area fluctuates considerably. In the past several generations, the region has prospered in time of national emergency. At other times, it has followed the general economy, and occasionally has been classified as a depressed area. Most often, however, employment is good, with salaries commensurate with the national scale. The wide diversity of industries stabilizes the area's economy and provides a labor pool of widely varying skills. Table 2 shows employment in 1952 and 1962, while Table 3 presents the average wage in the same years.[4] It might be stated that the trend to automation may, by requiring increased skills, tend to produce technological unemployment during the period required for retraining. Regional employment is expected to reach 860,000 by 1980, or an in crease of 38 percent over 1957's employment, as compared with a 49 percent increase in population for the same time period.[1] These percentages reflect the increasing proportion of old and young people in our modern population.

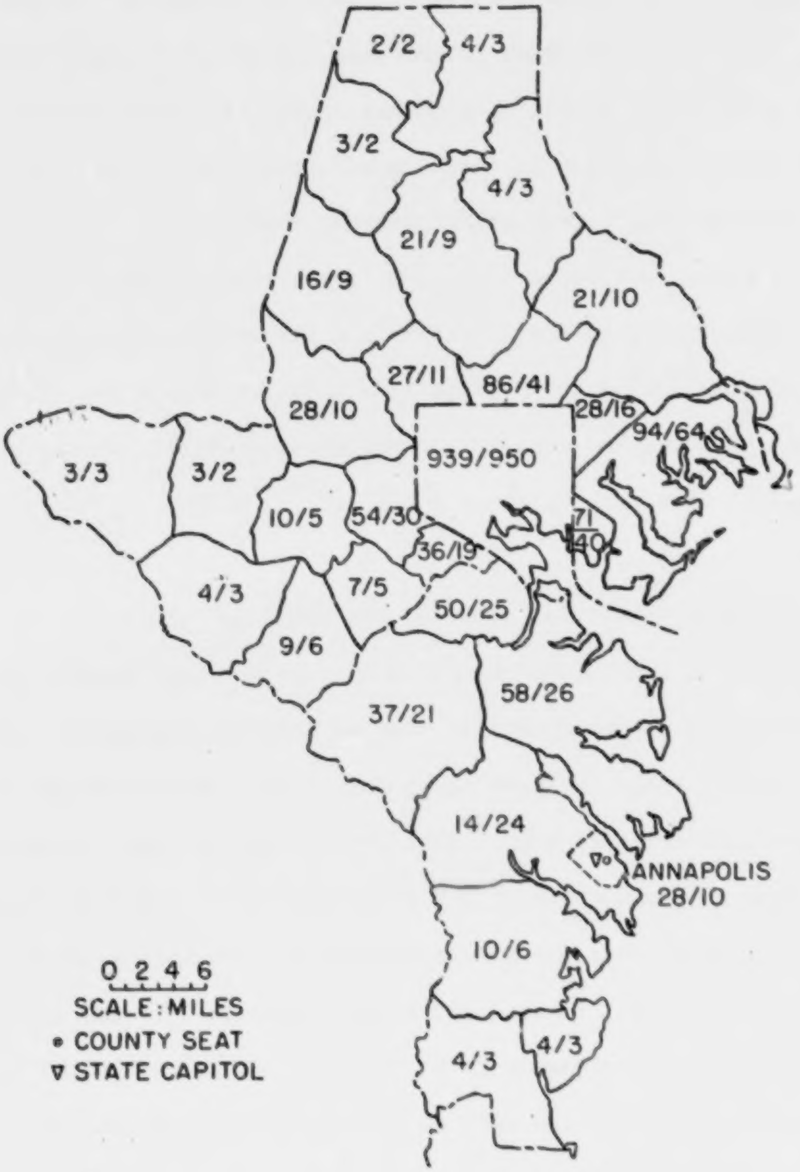

Figure 5. Metropolitan Baltimore (populations of each district for 1950 & 1960 are shown, i.e. 10/6 means 10,000 in 1960, 6,000 in 1950).

Table 3 shows that average wages for each of the counties covering the metropolitan area have increased relative to the national average for the 10-year period from 1952 to 1962. It is also worth noting that the average wage for Anne Arundel and Baltimore Countys is well above the national average.

The importance of the various industries to this area's economy is shown by Table 4.[7] It should be kept in mind, however, that manufacturing employees do not constitute the majority of workers in a large community. This is shown in Table 5.[3]

GENERAL GOVERNMENTAL STRUCTURE AND FUNCTIONS

The State of Maryland is governed by a constitution adopted in 1787 and amended from time to time during the intervening years. A General Assembly of two houses, a Senate and House of Delegates, is provided to enact needed legislation. Administration of these laws rests with the Governor, who is elected by popular vote for no more than two terms of 4 years each.

The Governor executes the laws of the State with the assistance of the several departments, commissions, committees, councils, and boards established for the administration of State matters. Health matters are the responsibility of the Board of Health and Mental Hygiene, whose members are appointed by the Governor, and are administered by the State Department of Health. Air pollution control is one such health function. The Board is empowered to issue orders, conduct hearings, and bring suit for contempt in case of noncompliance with orders.

Elected, also, are the Attorney General and the Comptroller. The Attorney General is responsible for legal advice to the Governor and the conduct of legal cases to which the State is a party. The comptroller has fiscal responsibility to the General Assembly and the electorate.

Table 4. EMPLOYEES BY MANUFACTURING INDUSTRY (1954)[a]

Industry	Number of Employees
Food and kindred products	23,900
Apparel and related products	16,200
Pulp and paper products	5,500
Printing and publishing	8,900
Chemicals and allied products	9,500
Stone, clay, and glass products	5,000
Primary metal industries	31,600
Fabricated metal products	15,300
Machinery, except electrical	7,800
Electrical machinery	11,000
Transportation equipment	30,700
Other industries	23,300
Total	188,700

[a] Reference 7.

Table 5. EMPLOYMENT IN VARIOUS INDUSTRIES (1962)[a,b]

Industry	Area	Balt. City	Anne Arundel Co.	Balt. Co.	Howard Co.
Mining and quarrying	790	70	-	720	-
Construction	34,860	22,930	3,140	8,060	730
Manufacturing	182,920	106,210	13,600	61,780	1,330
Transportation, commerce, and utilities	42,960	38,830	1,670	2,270	190
Wholesale and retail	124,950	92,940	9,050	21,750	1,210
Finance, insurance, and real estate	31,910	28,740	1,300	1,760	110
Service and other	48,150	35,280	3,110	9,190	570
Total	466,540	325,000	31,870	105,530	4,140
Percent of total	-	70	7	22	1

[a] Does not include railroad, government, nonprofit organization, domestic service, agriculture, or self-employed workers.

[b] Reference 4.

Baltimore is governed by the Mayor and the City Council. The Mayor is popularly elected and executes the wishes of the City Council through the several departments, boards, commissions, councils, and other executive and advisory bodies. The City Health Department is charged with air pollution matters through the Bureau of Industrial Hygiene.

Anne Arundel and Baltimore Countys have a charter form of government. The legislative unit is the County Council, which is charged with responsibility to provide means of exercising police powers. Laws and ordinances are executed by a county executive who is popularly elected. He is assisted by an administrator, who is recommended by the executive and appointed by the Council. Several departments, boards, and committees assist the executive. In Anne Arundel County, this type of home rule government was adopted early in 1965. Anne Arundel County air pollution control provisions are founded under zoning regulations, which are enforceable by the County Health Department. The health department in Baltimore County has a Section of Environmental Health, which includes a Division of Industrial Hygiene whose powers include the control of air pollution.

Howard County is governed by a Board of County Commissioners. Specific fields of control must be allocated by the General Assembly by approval of an ordinance on the subject. No definite air pollution legislation has been considered, but the county has acted under nuisance provisions of the law when necessary. No specific control agency exists, although the health department is usually the investigating agency for air pollution complaints.

It is interesting to note that neither Baltimore County nor Howard County contains any incorporated municipalities, while Anne Arundel includes only the City of Annapolis (and the town of Highland Beach, 1960 population: five). Thus, the Baltimore region has an advantage over most other metropolitan areas in that it has very few political subdivisions. The coordination and interrelationships of governmental programs within the region are much simpler than in most areas of similar size and population.

GENERAL CLIMATOLOGY

Monthly and annual standard climatological summaries published by the Weather Bureau are not usually directly applicable to air pollution problems. Such information may, however, be extracted and rearranged to aid in defining an air pollution problem. Furthermore, standard climatology enables one to obtain a broad understanding of the general effects of the weather on air pollution. Standard climatological compilations usually consist of monthly arithmetic averages of temperature, precipitation, visibility, cloudiness, and data for plotting wind roses of speed and direction.

Climatically Baltimore has more of the characteristics of a southern city than of a northern one. Its summer and winter, separated by a fairly short spring and a relatively long autumn, are generally temperate with few heavy rains, deep snows, or other critically unfavorable weather conditions. The nearness of Chesapeake Bay and the Atlantic Ocean to the east and the Appalachian Mountains to the west has a modifying effect on the weather.

Temperatures above 100°F occur on the average only twice in 3 years; temperatures below 0°F occur only once in about 8 years. The hottest months (June, July, and August) have a temperature average of about 76°F.

The months of December, January, and February are the coldest, with temperatures averaging 36°F and spells of extremely cold weather usually of short duration. The annual average temperature is about 56°F.

The appreciable difference (averaging 3°F) between temperatures experienced in the City of Baltimore and the suburban areas and nearby towns is due primarily to differences in exposure of the instruments and the heat island effect of the city.

Rainfall distribution throughout the year is rather uniform, varying from an average of 2.97 inches in November to 4.09 inches in August. Severe droughts seldom occur, although moisture deficiencies during the summer months are fairly frequent. Rains during the summer months occur with thunderstorms. Rain amounting to 0.01 inch or more occurs about 124 days a year, and a trace or more of snow occurs on an average of 26 days a year.

The sun is visible at least a few minutes on the average of 232 days each year, and the average annual sunshine is 59 percent of the total possible. Records show Baltimore has an average of 121 clear days, 132 partly cloudy days, and 121 cloudy days a year.[8]

Data indicate that March is the windy month, but there are no great seasonal fluctuations in the average wind movement. Lightest winds occur in the warmer months. The mean wind speed per month varies from 8.3 to 12.9 mph. Winds are from the northwest, west-northwest, and west about 30 percent of the time. Winds average 1 to 3 mph 4 percent of the time and 4 to 7 mph 26 percent of the time.

PRESENT POLLUTION LEVELS

SAMPLING PROGRAMS

In the past, within the metropolitan area little has been done outside the City of Baltimore to determine air pollution levels. Since 1963, the State has operated several suspended particulate samplers in Baltimore and Anne Arundel Countys. The counties around Baltimore are just beginning to move toward the control of air pollution and are including in their first steps ambient air sampling to help define present problems. In 1963 and 1964, with the facilities and cooperation of city and State health departments, oxidant sampling stations were placed in operation in all three counties and the city.

Within Baltimore, the City Health Department has maintained a sampling network that measures sulfur dioxide by a potentiometric method[9] (begun in 1955),[13] settled particulate by dustfall measurements[11] (begun in 1963),[13] and oxidants by the phenolphthalin method[12] (begun in 1963).[13]

The U.S. Public Health Service sponsors, through the National Air Sampling Network, a suspended particulate sampling station in downtown Baltimore, and limited gaseous sampling at the same site. In addition to this sampling, the Public Health Service, using a mobile laboratory stationed in downtown Baltimore, completed a 5-week period of intensive sampling for major known pollutants during the spring of 1964.[22] During this study, suspended particulate was collected with high-volume and AISI samplers. Sulfur dioxide, oxidants, nitrogen dioxide, nitric oxide, carbon monoxide, carbon dioxide, aldehydes, and hydrocarbons were sampled.

CITY AND COUNTRY PROGRAMS

Suspended particulate sampling was begun by the city in 1957 in residential and industrial areas. Residential values have remained fairly constant at a yearly average of around 100 micrograms per cubic meter ($\mu g/m^3$), Figure 6. The data from a commercial station established in 1957 show a slow drop in the suspended particulate yearly average to below 150 $\mu g/m^3$. The average at the industrial station showed a gradual drop until 1962, after which an increase resulted from a change in the station's local environment (heavy usage of a gravel parking lot nearby). Figure 8 shows the geometric averages for these data to be 88, 132, and 240 $\mu g/m^3$ respectively. These averages are believed to be high for the areas. considered.

A dustfall sampling network established over the city-wide area in 1963 gives a fairly good definition of the distribution of this pollutant over the city. Dustfall levels from 10 to 25 tons per square mile per month can be considered normal for urbanized areas. High levels occur as shown by isopleths (Figures 9, 10, 11, 12, and 13) around the bay area and north of the central area of the city. The isopleths seem to indicate the presence of high dustfall sources to the south and southeast of the city. High levels not revealed by the sampling network may also occur in other areas. The levels are highest during winter and spring and lowest during summer and fall.

The sulfur dioxide sampling program maintained by the city since 1955 shows a great reduction in the frequency of occurrence of high sulfur dioxide levels (Figure 7). From 1960 through 1963, sulfur dioxide levels have exceeded 2 ppm at the Canton station on numerous occasions. Concentrations greater than 0.5 ppm have been recorded twice at Morgan College and 14 times at Canton since 1960 when 90 and 140 occurrences were recorded at the respective stations. Reduced levels and occurrences have been

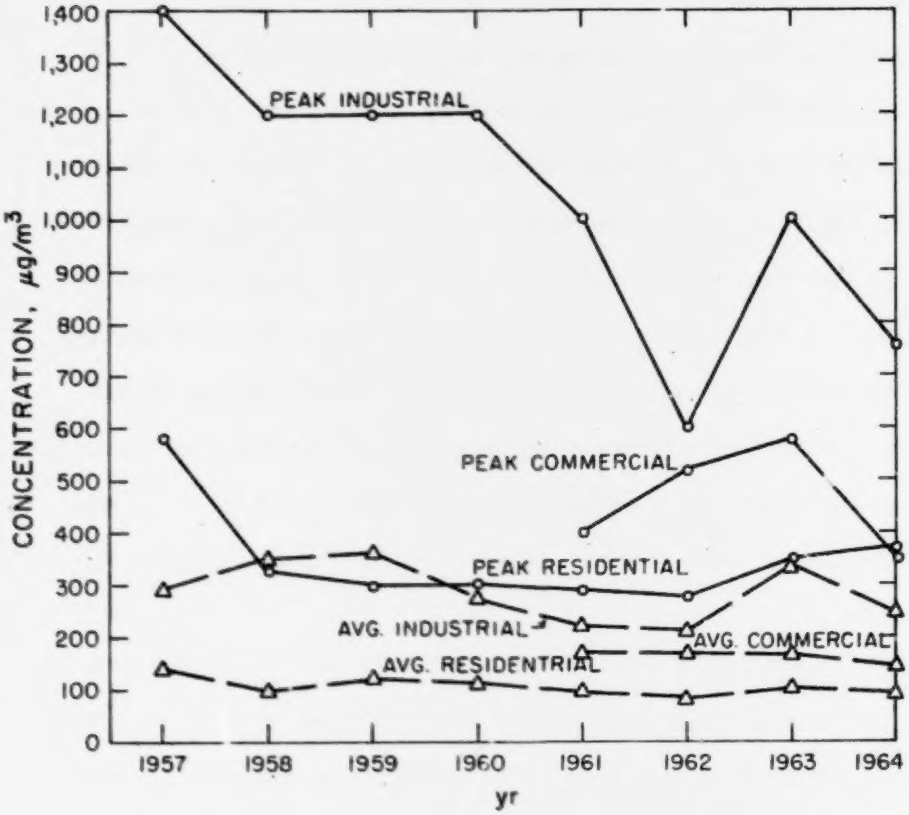

Figure 6. Suspended particulate average and peak values at selected sites.

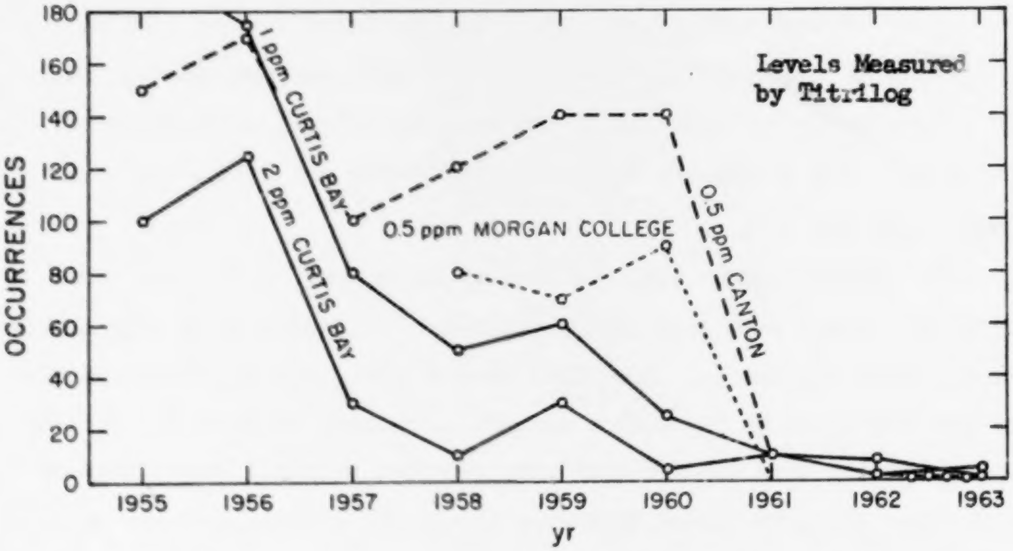

Figure 7. Frequency of sulfur dioxide concentrations.

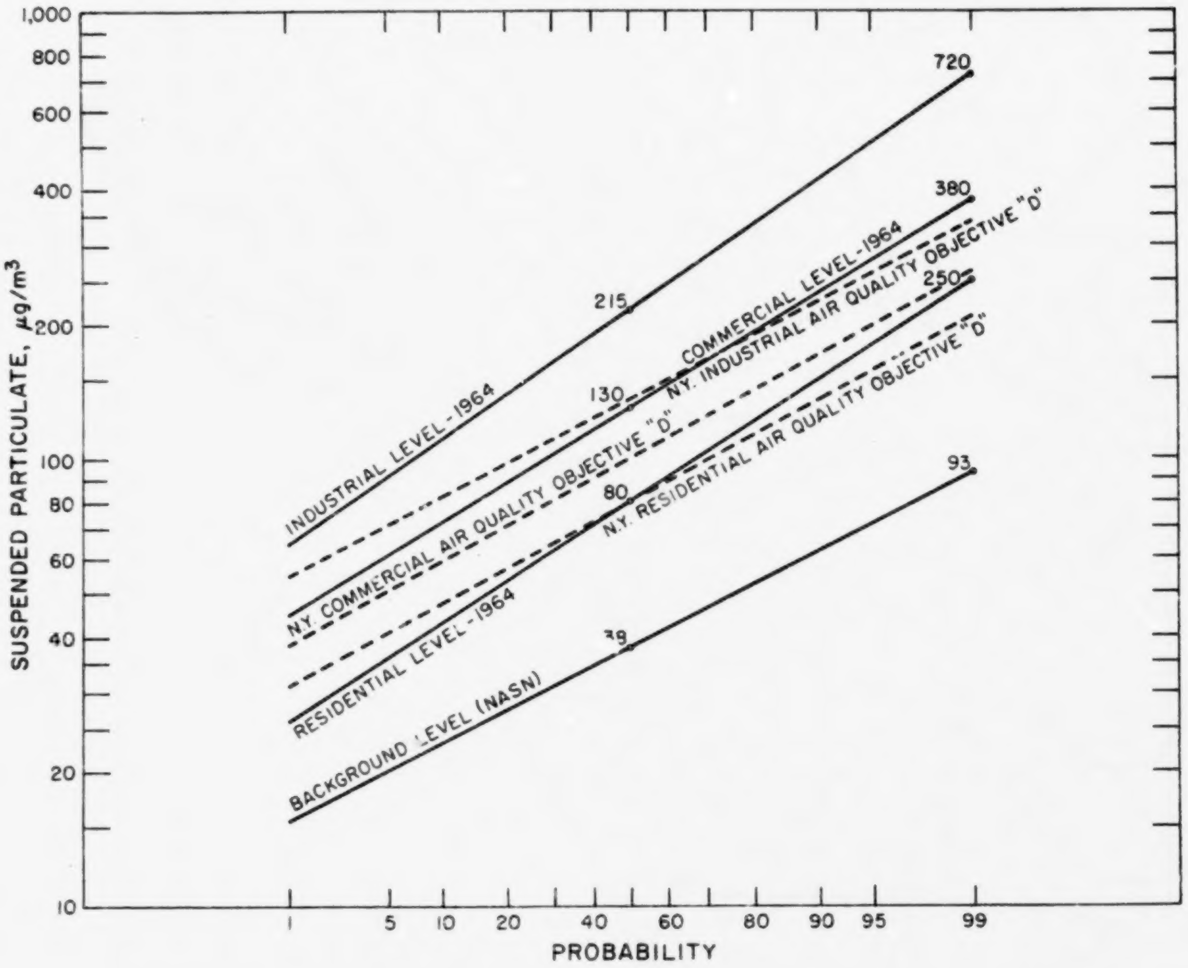

Figure 8. Suspended particulate pollution levels and suggested goals. (Baltimore, Maryland, Baltimore Health Dept. data).

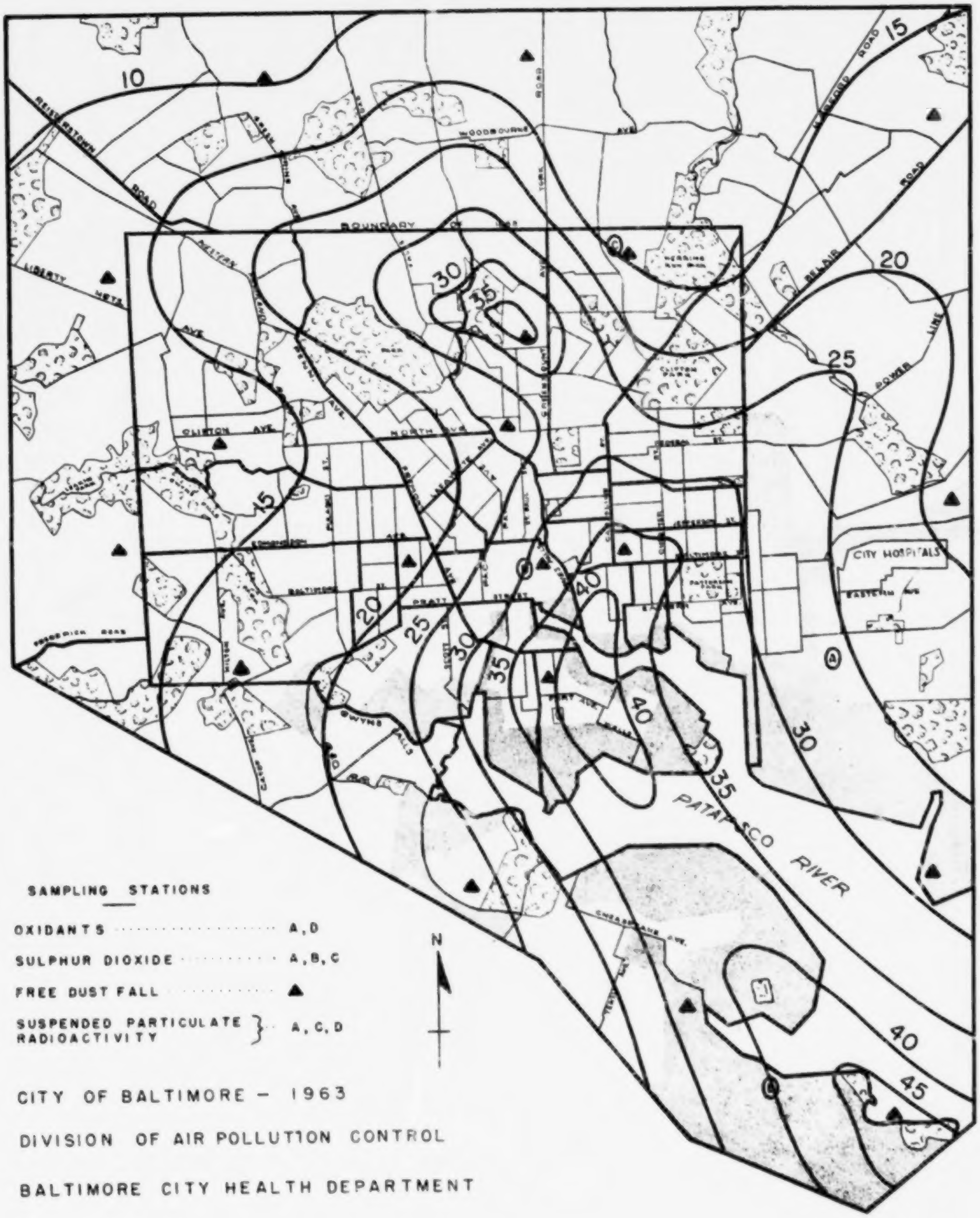

Figure 9. Dustfall isopleths 1964 (overall average 25 tons/mi^2/month).

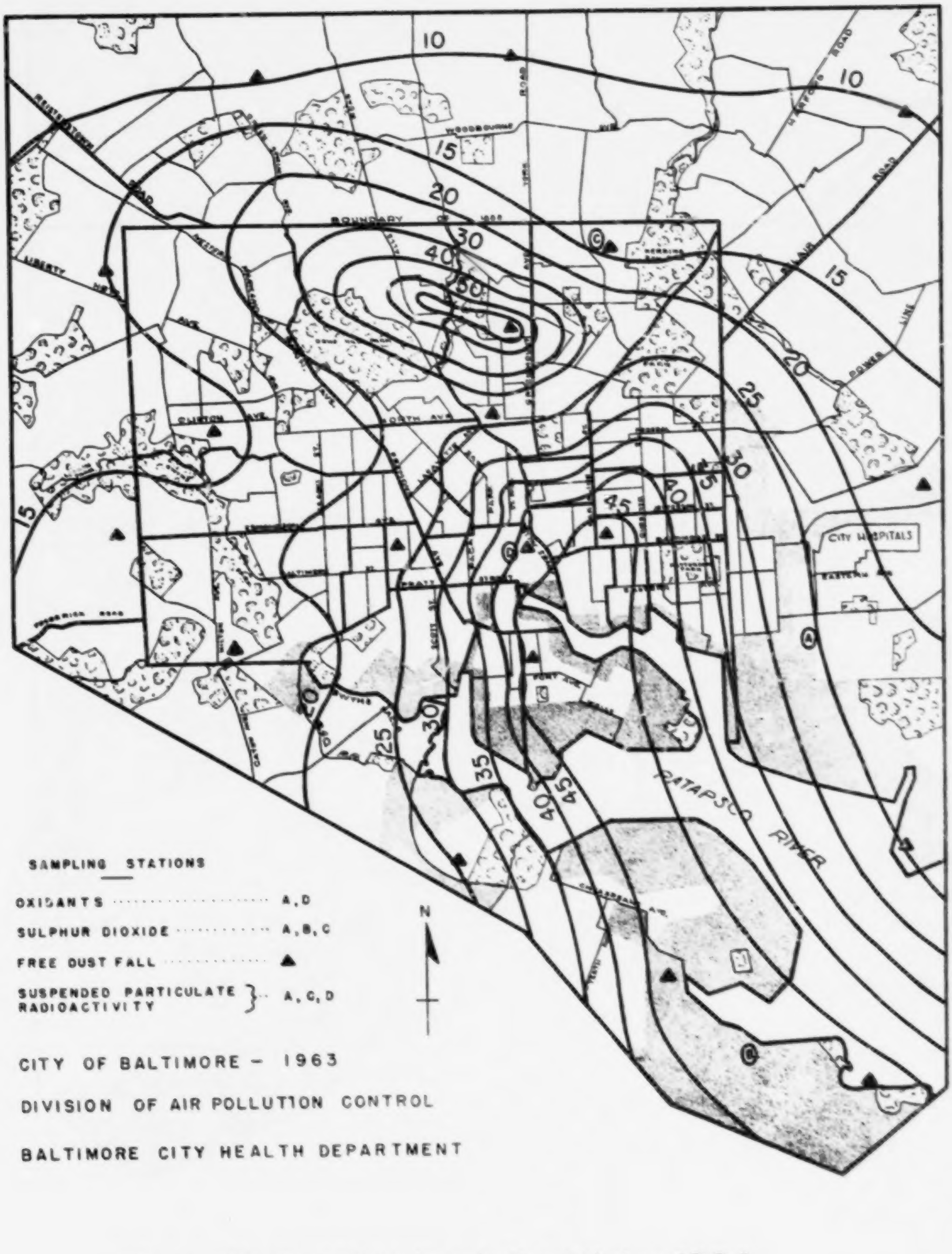

Figure 10. Dustfall isopleths Winter 1964
(overall average 32 tons/mi^2/month).

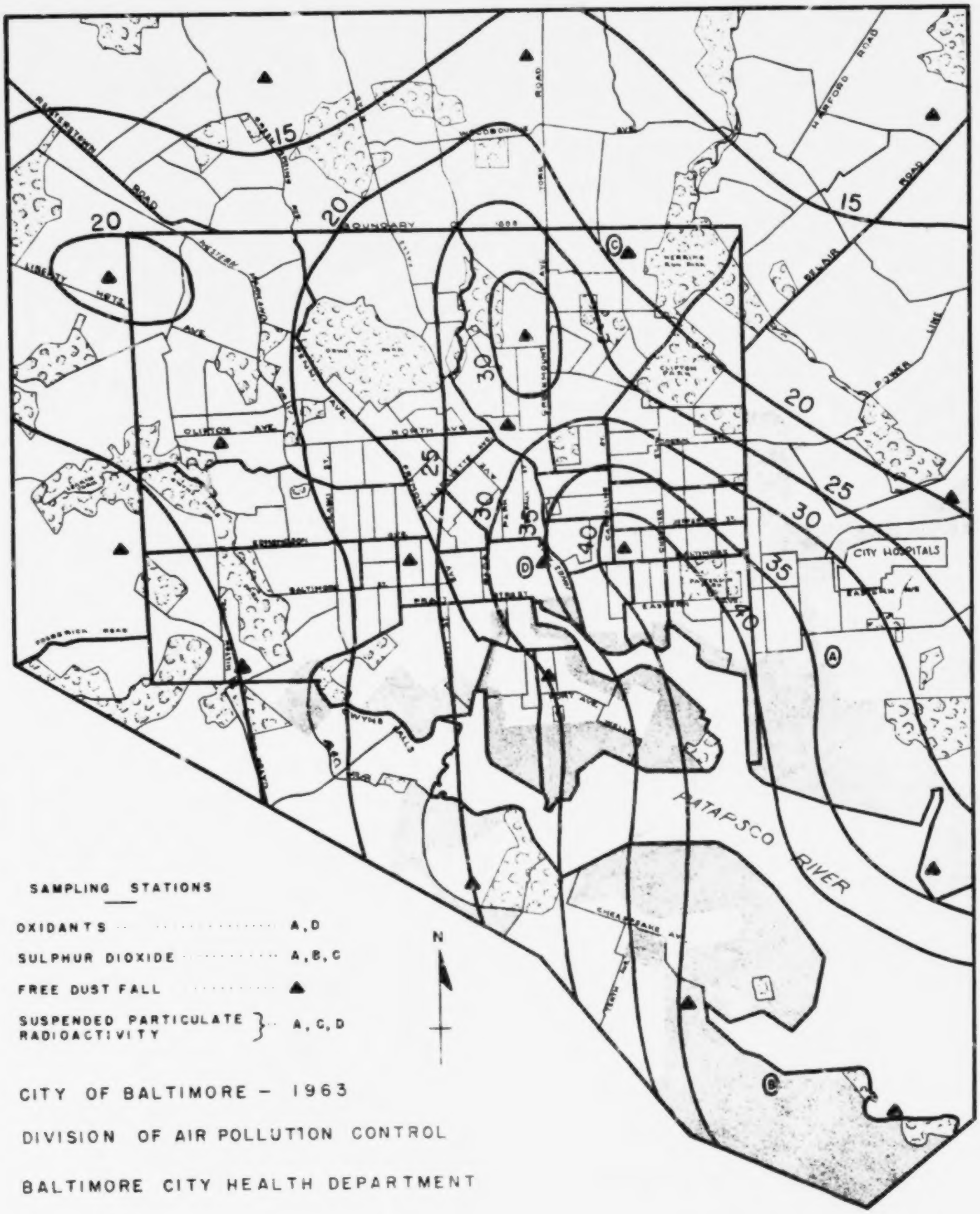

Figure 11. Dustfall isopleths Spring 1964 (overall average 28 tons/mi^2/month).

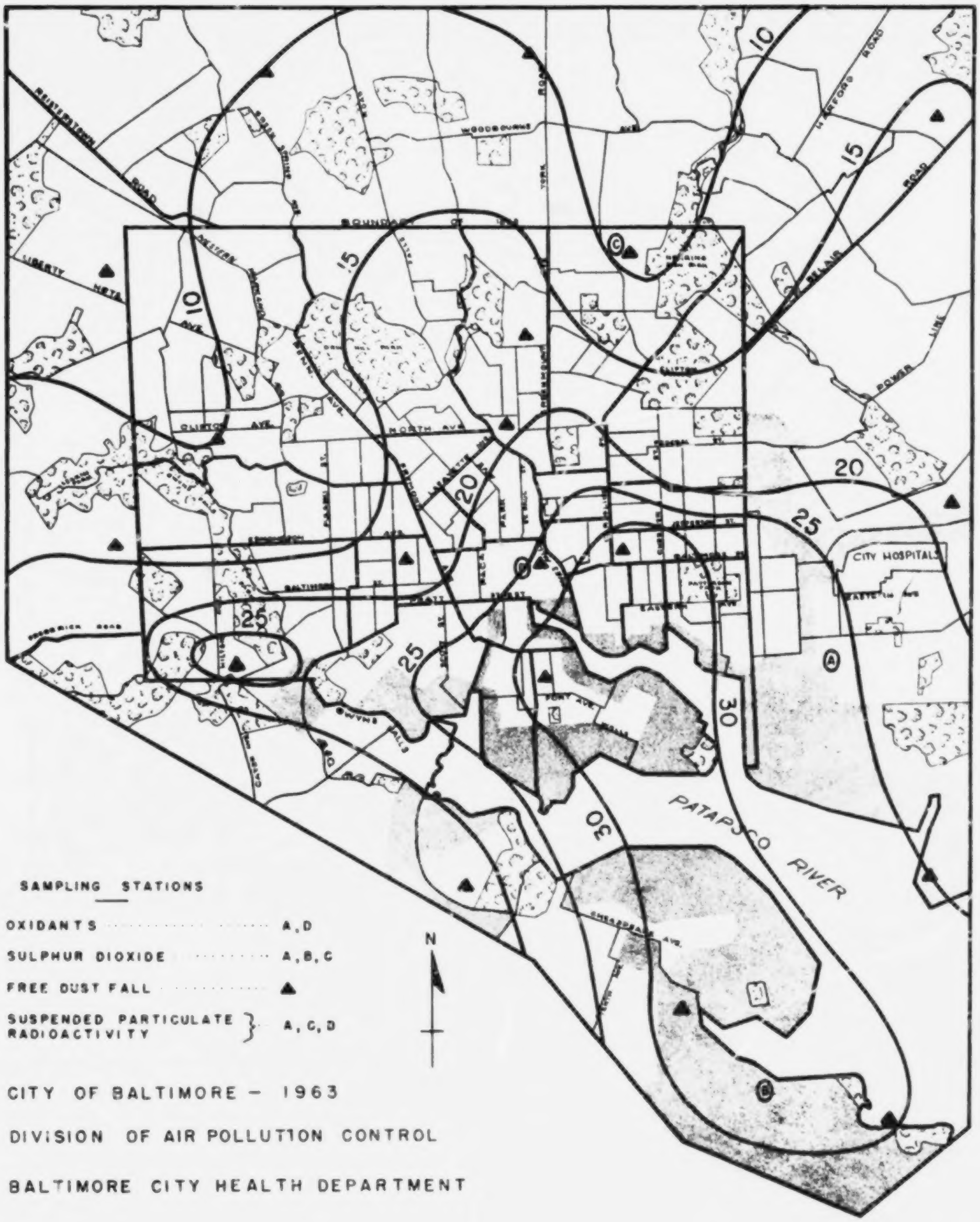

Figure 12. Dustfall isopleths Summer 1964 (overall average 20 tons/mi^2/month).

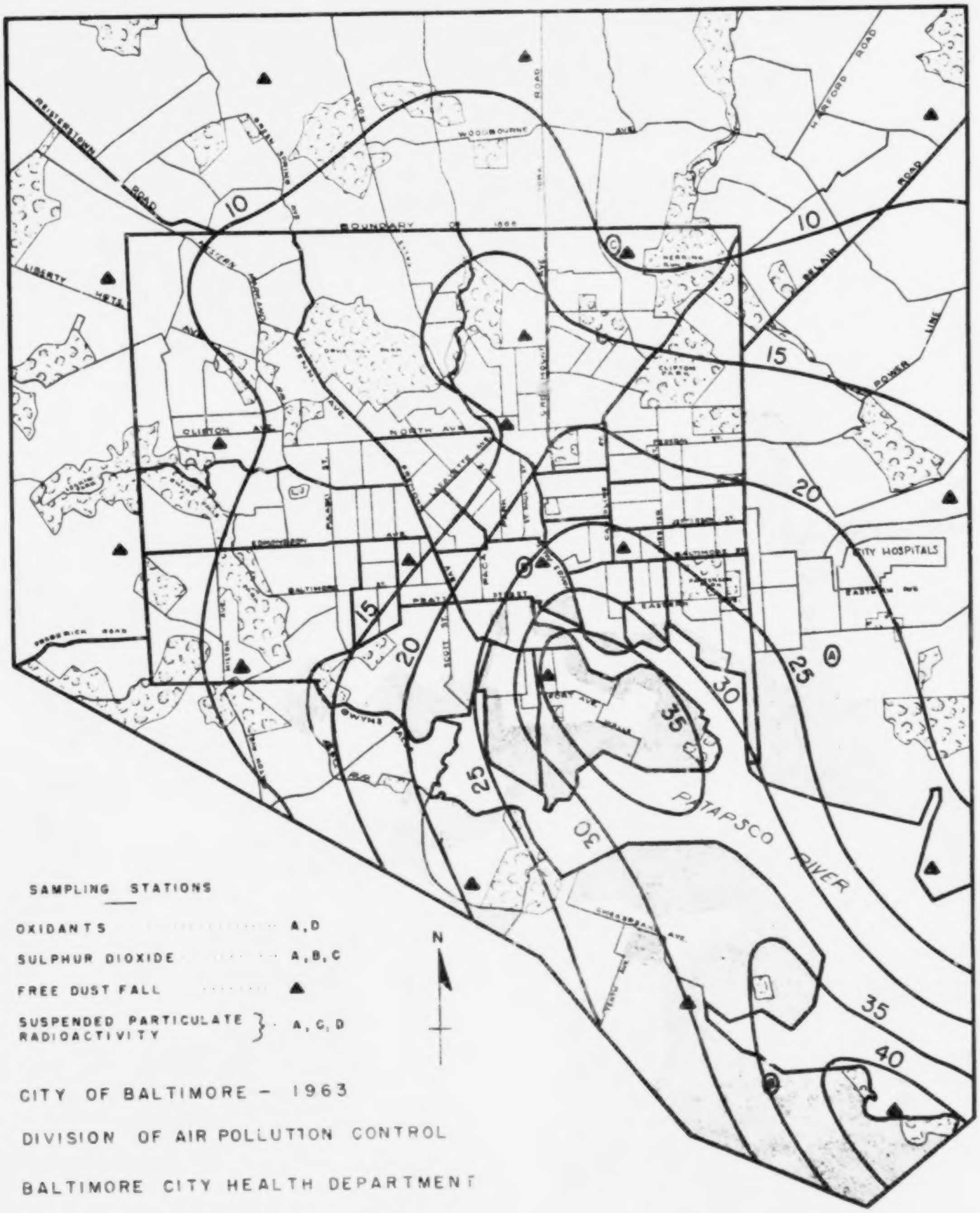

Figure 13. Dustfall isopleths Fall 1964 (overall average 20 tons/mi²/month).

steadily achieved in the Curtis Bay area, with 1963 data showing only one recorded level greater than 2 ppm and seven recordings greater than 1 ppm.

The threshold level for perceptible human response to sulfur dioxide is about 0.3 ppm. The California Standards for Ambient Air Quality refer to 5 ppm for 1 hour as a "serious" level, and 1 ppm for 1 hour as an "adverse" level of sulfur dioxide.[14] In Baltimore, since no 5-ppm concentrations have been recorded since 1959 and since the total hours of duration per month of measurable concentrations have been reduced to less than 5 hours for any month, it can be seen that the levels of this pollutant have been reduced to below the "serious" level and generally below the "adverse" level.

Oxidant, as ozone, is detectable by most people at concentrations around 0.15 ppm (phenolphthalin method). Adverse effects may be felt at concentrations in excess of 0.20 to 0.30 ppm. The California Standards for Ambient Air Quality designate 0.15 ppm for one hour by the potassium iodide method as an adverse level. The potassium iodide method usually gives values one-half as large as those determined by the phenolphthalin method.

In 1963, an average value of 0.16 ppm measured by the phenolphthalin method was recorded during the month of July, and in 1964, several stations recorded average values greater than 0.10 ppm during the summer months. Figures 14 and 15 show that sensory detectable levels of oxidant occur at all stations in the metropolitan network, primarily during the summer months. Irritant levels (concentrations greater than 0.20 ppm) occur fairly often during the summer season.

Air pollution complaints received by the Baltimore Health Department are divided into smoke and fly ash complaints and "other" complaints. Graphic representations of "other" complaints (Figures 16 and 17) show that these complaints have slowly increased since 1960. At the same time, however, the number of conditions causing "other" complaints has been dropping. This would seem to indicate that controls are being installed

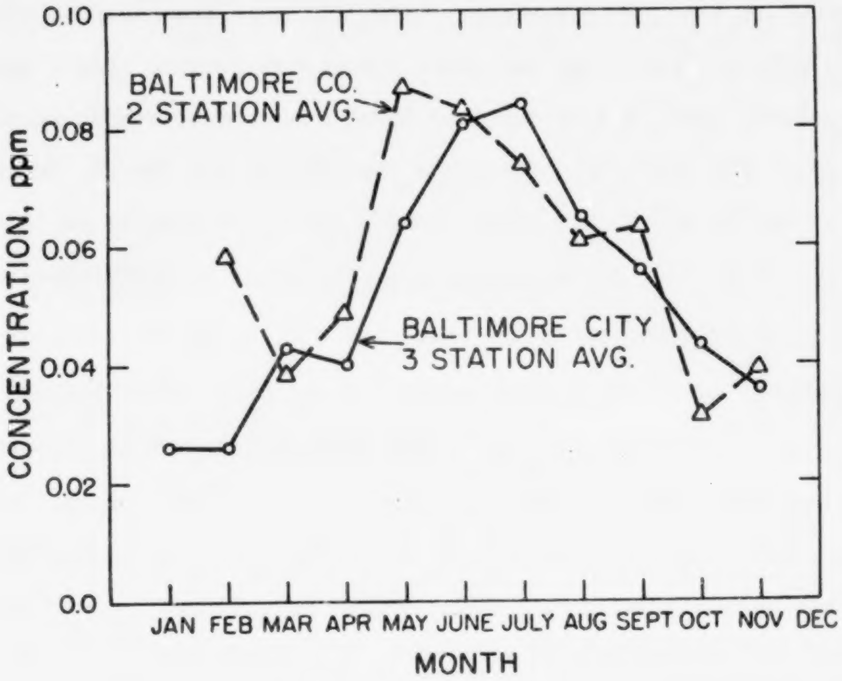

Figure 14. Average oxidant concentrations, 1964

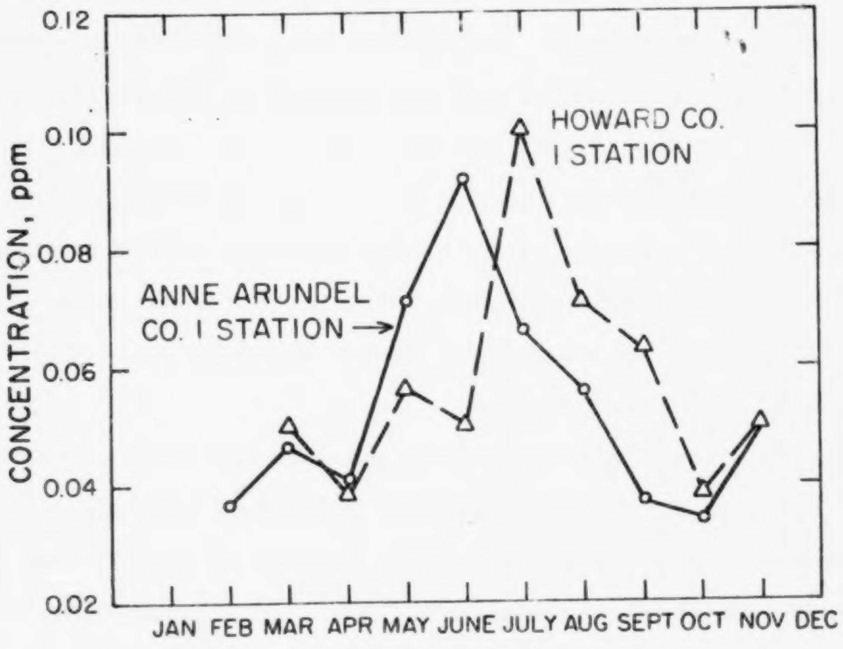

Figure 15. Average oxidant concentrations, 1964

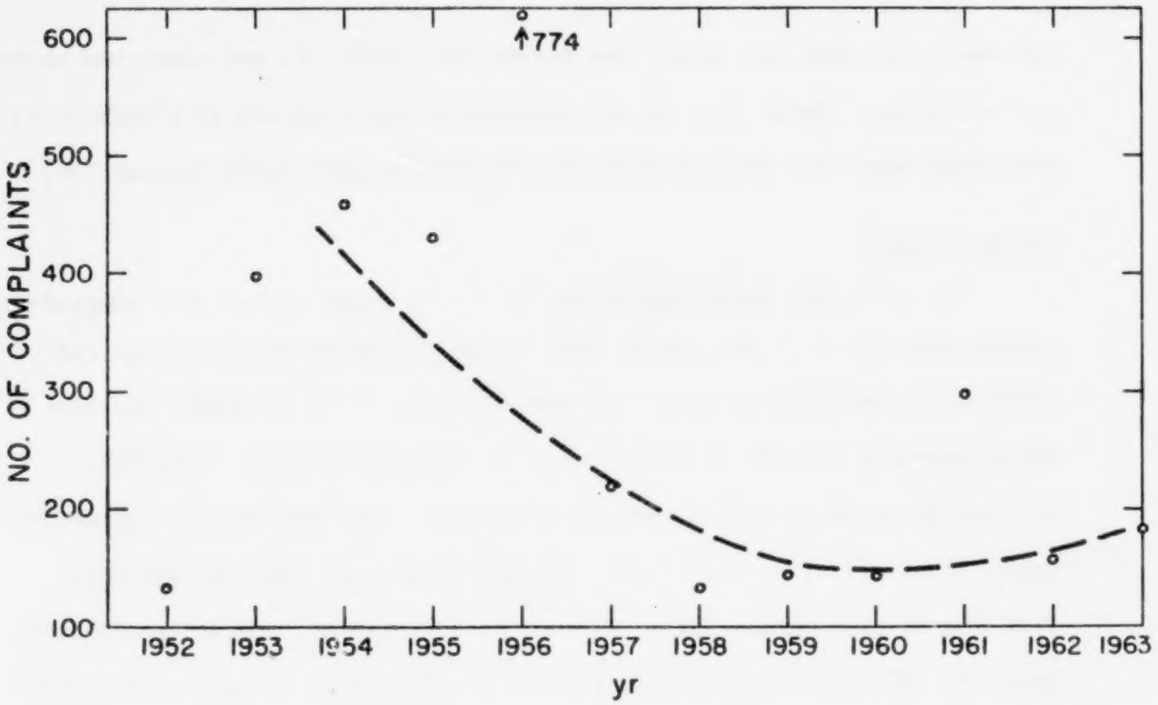

Figure 16. Air pollution complaints (excluding smoke and flyash complaints).

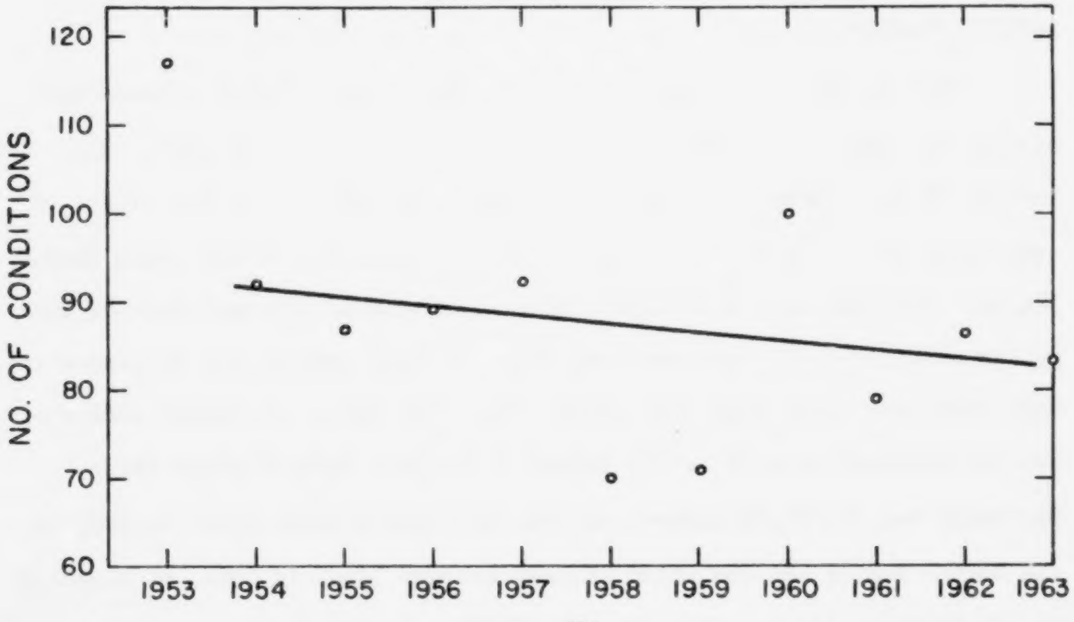

Figure 17. Conditions causing complaints (excluding smoke and flyash complaints).

and used, but that the public has become more aware of, and concerned about, air pollution. Smoke and fly ash complaints have remained at a high level, numbering more than 300 per year for the past 4 years (1960 through 1963).

STATE PROGRAM

In 1960, the State Department of Health began operating a suspended particulate (Hi-Vol) station at Fort Howard. Samples taken through 1963 indicate a good quality of air (geometric mean, 55 to 67 μg/m^3) but have shown steadily increasing levels of suspended particulate. A Hi-Vol station operated in 1963 at Annapolis showed a good quality air (geometric mean, 70 μg/m^3) with a much lower maximum value than that collected at Fort Howard (103 versus 191). Another Hi-Vol station, erected at Riviera Beach in 1963, indicated an air quality with a geometric mean of 83 μg/m^3 and a maximum of 178 μg/m^3. Dustfall samples taken at Annapolis and Fort Howard show low levels of dustfall (about 10 tons per square mile per month).

FEDERAL PROGRAM

The National Air Sampling Network (NASN) has operated a suspended particulate sampler in the downtown area of Baltimore since 1957. This sampler shows a geometric mean of 132 μg/m^3 compared to 119 for cities of comparable size (700,000 to 1,000,000 people) and 104 for the urban United States. NASN has also sponsored limited sampling of nitrogen dioxide and sulfur dioxide at the downtown area where 24-hour samples for 20 random days have been taken each year since 1961. The values collected indicate average nitrogen dioxide levels around 0.06 ppm. Table 6 shows that Baltimore had the fifth highest average nitrogen dioxide level in 1963 in the United States and the third highest average level in 1964, as measured by the National Air Sampling Network (NASN). Twenty-four-hour sulfur

Table 6. NATIONAL AIR SAMPLING NETWORK-24-HOUR NITROGEN DIOXIDE MEASUREMENTS IN PPM

Station	1963				1964			
	Samples	Min.	Max.	Avg	Samples	Min.	Max.	Avg
Albuquerque, New Mexico	16	0.02	0.04	0.03				
Atlanta, Georgia	16	0.03	0.08	0.04				
[a]Baltimore Maryland	26	0.04	0.10	0.06	24	0.03	0.19	0.07
[a]Birmingham, Alabama	15	0.02	0.13	0.05				
Boise, Idaho	16	0.02	0.05	0.03				
Boston, Massachusetts	21	0.03	0.08	0.05	19	0.02	0.08	0.05
Buffalo, New York	19	0.02	0.08	0.05	22	0.02	0.08	0.05
Charleston, West Virginia	22	0.02	0.08	0.05	26	0.02	0.11	0.05
Chattanooga, Tennessee	25	0.02	0.07	0.05	20	0.01	0.08	0.05
[a]Chicago, Illinois	24	0.04	0.07	0.06				
Cincinnati, Ohio	25	0.03	0.08	0.05				
Cleveland, Ohio	23	0.03	0.08	0.05	25	0.02	0.11	0.06
Columbus, Ohio	15	0.03	0.08	0.05				
Dallas, Texas	13	0.02	0.07	0.03				
Dayton, Ohio	25	0.02	0.06	0.04	25	0.02	0.12	0.05
Denver, Colorado	23	0.01	0.09	0.04	25	0.03	0.08	0.05
Des Moines, Iowa	22	0.01	0.06	0.03	25	0.02	0.06	0.03
Detroit, Michigan	26	0.03	0.11	0.05	23	0.03	0.08	0.05
East Chicago, Indiana	11	0.03	0.05	0.04	19	0.02	0.07	0.04
El Paso, Texas					17	0.02	0.07	0.04
Gary, Indiana					16	0.02	0.10	0.05
Guayanilla, Puerto Rico					16	0.01	0.03	0.02
Hartford, Connecticut	26	0.02	0.08	0.05	21	0.02	0.09	0.05
Houston, Texas	13	0.02	0.07	0.05				
Indianapolis, Indiana	26	0.03	0.10	0.05	25	0.03	0.10	0.05
Kansas City, Missouri	14	0.01	0.06	0.03	22	0.01	0.08	0.04
[a]Los Angeles, California	18	0.01	0.19	0.09				
Milwaukee, Wisconsin	21	0.01	0.07	0.04	26	0.02	0.07	0.04
Minneapolis, Minnesota	24	0.01	0.05	0.03	25	0.02	0.08	0.04
Nashville, Tennessee	24	0.01	0.07	0.04	26	0.02	0.12	0.05
[a]Newark, New Jersey	24	0.04	0.11	0.07	26	0.02	0.19	0.08
New Orleans, Louisiana	16	0.03	0.07	0.05				
New Haven, Connecticut	23	0.01	0.09	0.05	26	0.01	0.10	0.05
[a]New York City, New York	25	0.03	0.12	0.07	24	0.03	0.18	0.09
Norfolk, Virginia	16	0.03	0.05	0.04				
[a]Philadelphia, Pennsylvania	23	0.04	0.12	0.07				
Phoenix, Arizona	16	0.01	0.05	0.03				
[a]Pittsburgh, Pennsylvania	25	0.03	0.12	0.06	26	0.03	0.12	0.06
Portland, Oregon	24	0.03	0.14	0.05	23	0.02	0.10	0.05
Providence, Rhode Island	23	0.03	0.12	0.05	23	0.03	0.10	0.05
St. Louis, Missouri	26	0.02	0.06	0.04	26	0.02	0.10	0.04
Salt Lake City, Utah	22	0.02	0.08	0.04	25	0.03	0.07	0.05
San Antonio, Texas	13	0.01	0.06	0.04				
San Francisco, California	16	0.03	0.11	0.05				
San Juan, Puerto Rico	16	0.01	0.05	0.02				
Seattle, Washington	26	0.03	0.07	0.04	24	0.01	0.06	0.04
Tulsa, Oklahoma	11	0.02	0.11	0.05				
[a]Washington, D.C.	24	0.04	0.08	0.06				
Wichita, Kansas	25	0.02	0.07	0.03				
Wilmington, Delaware	26	0.03	0.09	0.05	22	0.03	0.09	0.05
Youngstown, Ohio	26	0.03	0.08	0.05	25	0.02	0.08	0.04

[a] Cities with average NO_2 levels as high as or higher than Baltimore's levels.

dioxide levels average 0.04 ppm, with maximums of 0.10 ppm. These gaseous pollutant levels apparently have been fairly constant during 1961 through 1964. These data, compared with those taken in other cities by NASN, Table 7, show Baltimore had the seventh highest average sulfur dioxide level in 1963 in the United States and the third highest average in 1964.

The intensive 5-week period of sampling by the U.S. Public Health Service mobile laboratory in March and April of 1964 showed that pollution due to particulate matter, nitrogen oxides, and sulfur dioxide is a significant problem in the downtown area. Suspended particulate concentrations determined by both AISI and High-Volume samplers were cited as "higher than desirable." Particulate concentrations exceeded 200 $\mu g/m^3$ 14 percent of the time and reached heavy (greater than 2.0 Cohs per 1,000 feet) soiling index values 22 percent of the study period at the downtown station. Geometric means of 136 $\mu g/m^3$ at the downtown station and 88 $\mu g/m^3$ at a residential station were determined. Sulfur dioxide averaged 0.6 ppm and reached an hourly concentration of 0.24 ppm, which is close to the threshhold taste level. Peak values undoubtedly exceeded this level. Photochemical smog was not detected during this spring period, but can probably be expected during the sunny summer months since relatively large concentrations of nitrogen oxides, hydrocarbons, and aldehydes were recorded. Nitrogen dioxide and nitric oxide arithmetic means were 0.06 and 0.09 ppm, respectively. These are well below the "serious" level of 3 ppm cited in the California Standards, but are approaching typical levels that occur on Los Angeles "smog" days (0.04 to 0.55 ppm and 0.12 to 0.60 ppm). Oxidant levels were consistently below the minimum detectable amount (about 0.02 ppm). Total hydrocarbon concentrations (average, 2 ppm) are typical of

Table 7. NATIONAL AIR SAMPLING NETWORK-24-HOUR SULFUR DIOXIDE MEASUREMENTS IN PPM

Station	1963				1964			
	Samples	Min.	Max.	Avg	Samples	Min.	Max.	Avg
Albuquerque, New Mexico	17	nil	0.01	nil				
Atlanta, Georgia	16	nil	0.03	0.01				
[a]Baltimore, Maryland	24	nil	0.09	0.04	25	nil	0.12	0.04
Birmingham, Alabama	15	nil	0.05	0.01				
Boise, Idaho	16	nil	0.02	nil				
Boston, Massachusetts	22	0.01	0.10	0.03	19	nil	0.15	0.02
Buffalo, New York	19	nil	0.05	0.02	21	nil	0.08	0.01
Charleston, West Virginia	23	nil	0.04	0.01	26	nil	0.04	0.01
Chattanooga, Tennessee	25	nil	0.07	0.01	21	nil	0.10	0.02
[a]Chicago, Illinois	24	0.01	0.30	0.11				
Cincinnati, Ohio	25	nil	0.06	0.02				
[a]Cleveland, Ohio	23	nil	0.10	0.04	25	nil	0.11	0.03
Columbus, Ohio	15	nil	0.04	0.01				
Dallas, Texas	14	nil	0.01	nil				
Dayton, Ohio	24	nil	0.04	0.01	25	nil	0.04	0.01
Denver, Colorado	23	nil	0.02	0.01	25	nil	0.02	0.01
Des Moines, Iowa	24	nil	0.03	0.01	25	nil	0.02	nil
Detroit, Michigan	26	nil	0.07	0.02	23	nil	0.04	0.01
[a]East Chicago, Indiana	11	0.01	0.09	0.04	20	nil	0.09	0.04
El Paso, Texas					17	nil	0.09	0.03
Gary, Indiana					30	nil	0.09	0.01
Guayanilla, Puerto Rico					16	nil	0.01	nil
Hartford, Connecticut	26	0.01	0.09	0.03	20	nil	0.08	0.03
Houston, Texas	13	nil	0.01	nil				
Indianapolis, Indiana	26	nil	0.05	0.02	25	nil	0.10	0.02
Kansas City, Missouri	14	nil	0.11	0.01	19	nil	0.01	nil
Los Angeles, California	18	nil	0.01	nil				
Milwaukee, Wisconsin	22	nil	0.03	0.01	26	nil	0.02	0.01
Minneapolis, Minnesota	24	nil	0.09	0.02	25	nil	0.03	0.01
Nashville, Tennessee	24	nil	0.05	0.01	26	nil	0.04	0.01
[a]Newark, New Jersey	25	0.01	0.32	0.08	26	0.01	0.25	0.08
New Orleans, Louisiana	16	nil	0.01	nil				
[a]New Haven, Connecticut	23	0.01	0.13	0.04	25	nil	0.08	0.02
[a]New York City, New York	25	0.04	0.38	0.15	24	0.05	0.42	0.17
Norfolk, Virginia	15	nil	0.04	0.01				
[a]Philadelphia, Pennsylvania	25	0.02	0.27	0.10				
Phoenix, Arizona	17	nil	0.01	nil				
[a]Pittsburgh, Pennsylvania	25	0.01	0.12	0.04	26	0.01	0.07	0.03
Portland, Oregon	24	nil	0.06	0.02	24	nil	0.04	0.01
[a]Providence, Rhode Island	22	nil	0.11	0.05	21	nil	0.16	0.04
St. Louis, Missouri	26	nil	0.10	0.02	26	0.01	0.11	0.03
Salt Lake City, Utah	22	nil	0.04	0.01	24	nil	0.03	0.01
San Antonio, Texas	14	nil	nil	nil				
San Francisco, California	16	nil	0.01	nil				
San Juan, Puerto Rico	15	nil	nil	nil				
Seattle, Washington	26	nil	0.07	0.02	24	nil	0.03	0.01
Tulsa, Oklahoma	11	nil	0.01	nil				
Washington, D.C.	24	nil	0.08	0.03				
Wichita, Kansas	25	nil	0.01	nil				
[a]Wilmington, Delaware	26	0.01	0.13	0.05	22	nil	0.08	0.03
[a]Youngstown, Ohio	26	0.01	0.10	0.04	26	nil	0.06	0.02

[a] Cities with average SO_2 levels as high as or higher than Baltimore's levels.

those measured in other large cities. Aldehydes averaged 0.04 ppm, with a maximum of 0.2 ppm occurring.

CONCLUSIONS

From this body of data gathered by the various agencies concerned with metropolitan Baltimore's air pollution problem, the following statements can be made:

1. A comprehensive body of data that defines the area's air pollution problems adequately does not exist.
2. Some basic data from which conclusions can be drawn is available from various agencies.
3. These data apply primarily to the City of Baltimore.
    a. Suspended particulate matter is excessively high in the industrial area sampled. Samples taken in residential and commercial areas record high levels.
    b. The dustfall network defines the distribution of dustfall over the city area fairly well. With the addition of 10 to 20 stations, the dustfall network can be extended over the metropolitan area to give a more complete picture of the distribution of dustfall. Dustfall levels are high in the river area and north of the city's central area.
    c. The sulfur dioxide problem has been greatly reduced in the recent past, but remains a significant problem.
    d. Oxidant levels reach irritant levels during the summer months in the counties as well as in the city.
    e. Levels of nitrogen oxides, hydrocarbons, aldehydes, and oxidant measured indicate a strong potential for the creation of photo-

chemical smog during the summer months.

4. A sampling network that will give a better definition of the levels of the major pollutants present at various locations within the metropolitan area should be established.

SOURCES OF AIR POLLUTION

To gauge the effects of any control efforts to be introduced, some knowledge must be possessed on the air pollution sources located in various sectors of the metropolitan area. Controls required on certain types of equipment or processes will only be effective in improving the air pollution situation if the equipment or processes to be controlled are significant sources of problem pollutants and if their emissions cause or contribute to air pollution problems. For the best control program then, an air sampling network must be set up to define problem areas and pollutants, and a source inventory should be carried out simultaneously to point out the sources that can be most easily and economically controlled for the most efficient resolution of air pollution problems. At present, little information beyond that of a general nature is available on the sources of air pollution. Even those data on the total amounts of fuel used seem to be questionable in some respects.

TOTAL FUEL USED

An approximation of the total fuel used in stationary sources has been obtained from the fuel suppliers or their association. The data are summarized and described in Tables 8 and 9.

These figures include residential, commercial, and some industrial uses. Much of the industrial fuel apparently comes from sources other than local suppliers. This is borne out by the "1963 Census of Manufacturers-Fuel and Electrical Energy Consumed in Manufacturing Industries: 1962" by

Table 8. FUEL CONSUMPTION, 1963

Fuel	Total	Balt. City	Anne Arundel Co.	Balt. Co.	Howard Co.
Gas, ft^3 (millions)	50,000	-	-	-	-
Oil, gal (thousands)	225,000	137,400	26,600	55,400	5,600
Coal and coke,[a] tons (thousands)	6,500	4,200	435	1,800	65

[a] Does not include fuel used at Sparrow's Point or utility fuel use.

Table 9. TYPICAL ANALYSIS OF FUELS

Fuel	Sulfur	Ash	Volatiles	Fixed Carbon
Coal	1.19 - 3.50%	7.0 - 9.2%	23.5 - 35.8%	53 - 63.5%
Oil	0.18 - 4.00%	0.0 - 1.1%		

Table 10. ESTIMATED RESIDENTIAL FUEL USAGE, 1960

Fuel	Total	Balt. City	Anne Arundel Co.	Balt. Co.	Howard Co.
Gas, ft^3 (millions)	19,300	9,900	1,700	7,500	180
Oil, gal (thousands)	255,400	155,200	28,500	64,800	6,900
Coal and coke, tons (thousands)	236	164	24	43	5

the Bureau of Census which shows 683,000 tons of coal, 279,000 barrels of fuel oil, and 12,732 million cubic feet of gas purchased by industry in the Baltimore area.

RESIDENTIAL SPACE HEATING FUEL USE

Residential usage can be estimated from housing census data, degree-days, and national average fuel-usage factors. The factors used for gas, oil, and coal are 22.5 cubic feet per five-room house per degree-day, 0.18 gallons per five-room house per degree-day, and 0.0012 ton per five-room house per degree-day, respectively. Housing census data for 1960 show that of 590,621 units 11 percent use coal, 44 percent use oil, and 44 percent use gas.

There is apparently a considerable discrepancy between the estimated residential fuel oil usage, Table 10, and the total fuel oil usage, Table 8. Apparently considerable conversion from fuel oil to gas or electricity for space heating has occurred, the usage factors are in error for the area, or the data received on the total fuel oil used in the area are inaccurate.

UTILITY FUEL USE

Utility fuel use for the purpose of generating power and steam often constitutes a large proportion of the total fuel usage. Table 11 summarizes this fuel use, and Table 12 describes the fuel analysis. This utility fuel use is not included in the total fuel use of Table 8.

MANUFACTURING PLANTS

The port area of Baltimore, as a result of its capacity for handling large volumes of material, has several very large industries. Of primary importance in the emission of pollutants are the industries shown in Table 13. Even more important is the fact that more than 95 percent of the larger

Table 11. UTILITY FUEL USE

Location	Coal, tons (thousands)	Heavy oil, gal (thousands)	Light oil, gal (thousands)
Balt. City, Gould St.	284	375	
Balt. City, Westport	250	784	
Balt. City, Pratt St.	32		
Balt. City, Wyoming St.		94	
Balt. City, Terminal Sta.	55	1940	
Anne Arundel Co. Wagner Sta.	634		125
Balt. Co., Crane St.	800	253	69
Balt. Co., Riverside Sta.	449	1009	
Total	2504	4455	194

Table 12. TYPICAL UTILITY FUEL ANALYSIS

Fuel	Sulfur	Ash	Volatiles	Fixed Carbon
Coal	1.19 - 2.39%	7.0 - 9.2%	23.5 - 35.8%	53 - 63.5%
Oil	0.18 - 2.31%	0.00 - 0.18%		

Table 13. NUMBERS OF PLANTS IN SELECTED MANUFACTURING CLASSIFICATIONS[a,b]

Type of plant	Large vs. small plants[c]	Balt. City	Anne Arundel Co.	Balt. Co.	Howard Co.
Lumber and wood products	20- 71	24	18	21	8
	20+ 28	16	1	9	2
Paper and allied products	20- 14	14	0	0	0
	20+ 41	32	0	9	0
Chemicals and allied products	20- 74	61	4	7	2
	20+ 67	61	4	2	0
Petroleum and coal products	20- 9	6	0	3	0
	20+ 8	8	0	0	0
Rubber and plastic products	20- 9	9	0	0	0
	20+ 14	11	1	2	0
Stone, clay and glass products	20- 53	30	8	12	3
	20+ 35	21	1	12	1
Primary metals industries	20- 14	12	0	2	0
	20+ 23	18	0	5	0
Fabricated metal products	20- 117	86	3	24	4
	20+ 77	63	0	12	2
Machinery, except electrical	20- 111	87	7	16	1
	20+ 46	34	1	10	1
Total industries	20-1194	929	93	150	22
	20+ 833	694	27	100	12
Total	2027	1623	120	250	34
Percent of total industries	20- 100	78	8	12	2
	20+ 100	83	3	12	2
Percent of total	100	80	6	12	2

[a] Reference 7.

[b] This table shows that 4/5 of the area's industries are located within the city and more than 9/10 are located in the combined city and Baltimore County jurisdictions.

[c] 20-, plants having less than 20 employees.
20+, plants having more than 20 employees.

industries are located within the combined city and Baltimore County areas. It is very probable that more than 95 percent of the area's industry lies within 10 miles of the city's downtown area.

Figure 18 shows the approximate locations of the major pollutant sources in Baltimore City. To determine these major sources, a detailed appraisal of potential major sources was made by the Baltimore City Health Department. Those sources shown in Howard and Baltimore Countys were located by means of a brief appraisal of past problem sources and knowledge of the area accumulated by County Health Department personnel. No source inventory was done for Anne Arundel County. It is very possible that a number of large sources are located in the northern part of this county near Baltimore City.

TRANSPORTATION

Because this area is a distribution center for a large section of the county, much of the large truck transportation is of a transient nature. Baltimore is also located on several of the major north-south highways on the east coast. Because of the presence of so many vehicles, both truck and automobile, of foreign registry, it is very difficult to estimate accurately the amount of fuel used by these vehicles in the area. The figures for fuel usage in Tables 14 and 15 are based on the ratio of vehicles registered in the county or city to the total vehicles registered in the State times the fuel sold in the entire State. Logically, it would seem that much of the diesel fuel oil is not used in the metropolitan area since most trucks fill their tanks before leaving the metropolitan area for their destinations. On the other hand, it is safe to assume that practically all of the gasoline sold in the metropolitan area is used in the metropolitan area and that a large amount of gasoline is brought into and consumed in the metropolitan area by throughway traffic.

The gasoline and diesel fuel usage figures are estimates based on the premise that the amount of fuel used in a given county or city is

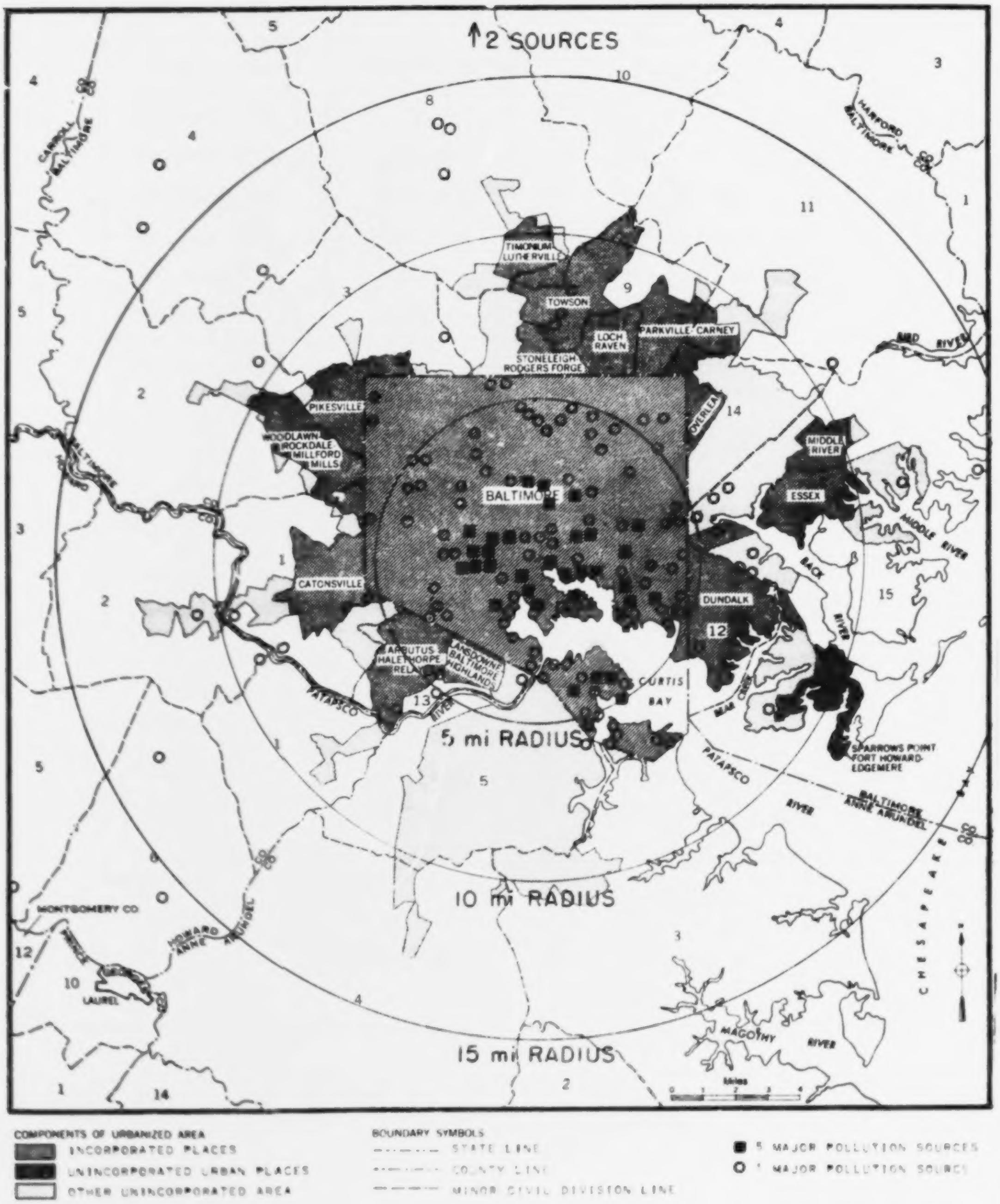

Figure 18. Major pollution sources (excluding Anne Arundel County).

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Table 14. GASOLINE VEHICLE REGISTRATION AND GASOLINE USAGE, 1962

Area	Registration[a]	Usage, (gal)
State	1,213,211	1,081,306,794
Region	575,009	512,500,000
Baltimore City	265,348	236,400,000
Baltimore County	211,308	188,300,000
Anne Arundel County	80,778	72,100,000
Howard County	17,575	15,700,000

[a] Motorcycles, farm vehicles, and special licenses not counted.

Table 15. DIESEL VEHICLE REGISTRATION AND DIESEL FUEL USAGE, 1962

Area	Registration	Usage, (gal)
State	15,821	45,142,059
Region	8,981	25,600,000
Baltimore City	6,604	18,825,000
Baltimore County	1,630	4,645,000
Anne Arundel County	597	1,703,000
Howard County	150	427,000

Table 16. INVERSION DATA[a]

Season	Inversion frequency, % of total hours	Inversion frequency, % observed	Nighttime	
			Surface wind < 7 mph	Cloud cover > 3/10
Winter	25	45	36	37
Spring	23	50	34	40
Summer	30	50	[illegible]	55
Fall	30	50	42	53

[a] Reference 16

directly proportional to the registration in its area, and that the fuel used in the State is equal to the fuel sold in the State.

Figure 19 shows the rapid growth rate of motor vehicle registrations. Over the past 18 years, registrations have increased 60,000 vehicles each year. This indicates that by 1970 about 2,000,000 vehicles will be registered in Maryland. If a constant ratio of regional to State registrations is assumed, it can be shown that by 1970 more than 730,000 vehicles will be registered and presumably operating in the region. This means that pollutants from automobiles and other vehicles will increase by more than 25 percent if no controls are used. Blowby devices, which decrease auto hydrocarbon emissions by 15 to 25 percent, have been installed on automobiles since 1963. Also, in 1966 or 1967, automobiles may be produced with engine modifications designed to reduce hydrocarbon and carbon monoxide emissions by over 80 percent. If 60 percent of the area's automobiles are equipped with these pollution-reducing devices by 1970, it can be calculated that pollution from automobiles will have been reduced by about 30 percent of what is emitted today from automobiles, despite the large increase in registrations.

SPECIFIC MAJOR POLLUTION SOURCES INDICATED BY COMPLAINTS

Even though certain sources have been indicated by neighbors as major contributors to air pollution, measurements in the vicinity of these sources often do not confirm the allegations. Most often, complaints arise either from newly arrived residents or by older residents against newly located industry or against conditions resulting from a change in process or breakdown of equipment. Complaints to date concern nuisance conditions rather than health hazard conditions. Several nuisance conditions have continually recurred and have aroused justified complaints.

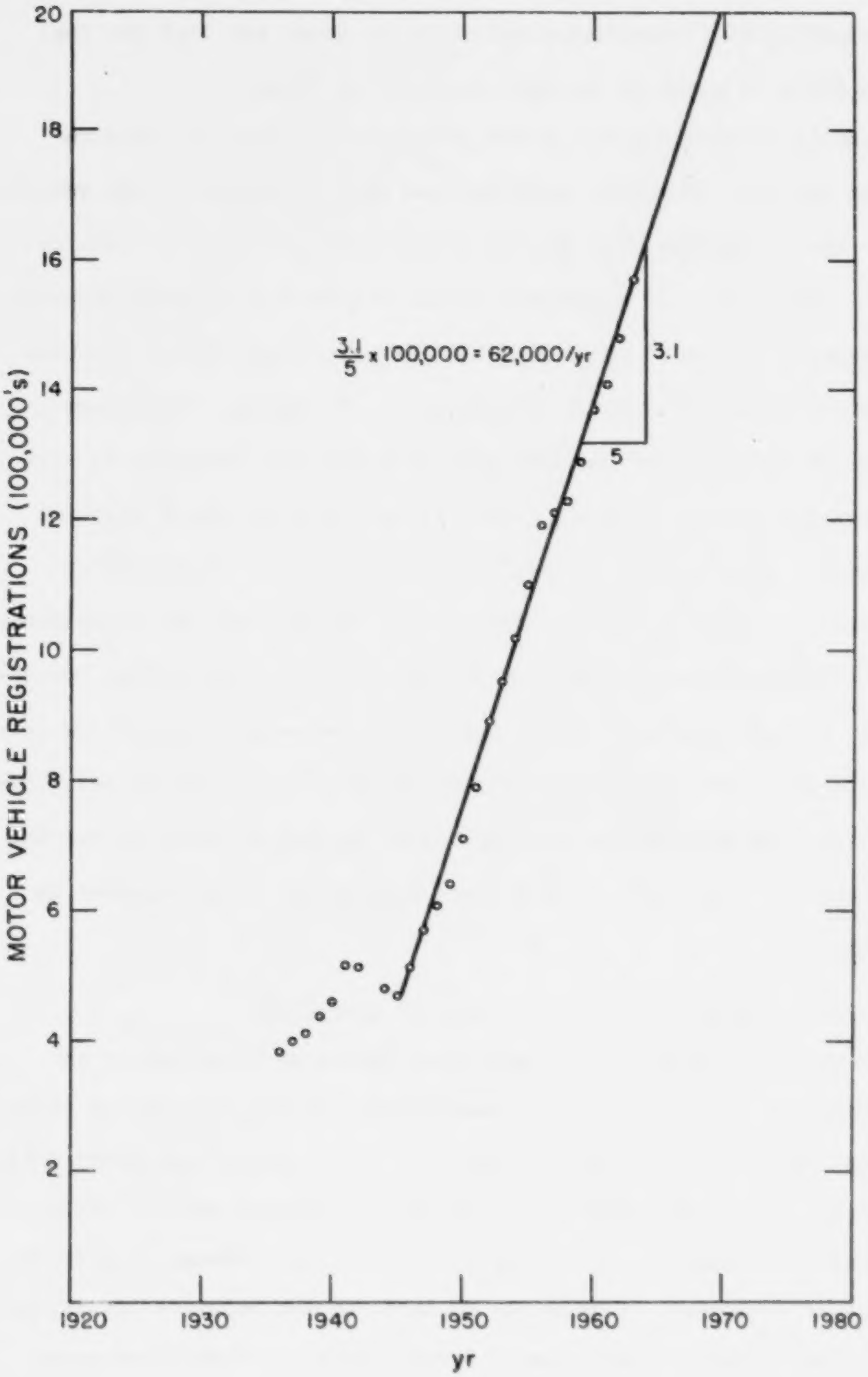


Figure 19. Motor vehicle registrations,
Maryland, 1936-1963.

In Anne Arundel County, laundries and dry cleaning plants have been associated with heavy smoke emissions and solvent odors. Dust and odor emissions from fertilizer and pigment plants in the city affect a small segment of the northeastern part of the county. Hydrogen sulfide from decaying sea vegetation near sea shore communities creates a serious problem during the summer. The latter problem is well removed from the metropolitan area, occurring near Annapolis and south of Annapolis.

The most noticeable air pollution sources in Howard County are a rendering plant, an asphalt plant, and a rock-crushing operation. Each affects very few people. Reasonable controls are maintained, although the rendering plant does not do as well as can be expected. Open burning, which is practiced by junk yards, is also a problem.

Baltimore County has a variety of potential sources. Present industrial zoning is based on traditional land use, as well as on current accessibility to adequate transportation facilities. This has tended to cause some industrial encroachment on residential areas. Residential areas have also developed near industrial zones. In consequence, objectionable conditions have developed at residences, such as those in the vicinities of basic steel production, a maker of special steels, a processor of cattle and poultry food base, and the city sewage treatment plant. Other conditions have been reported sporadically, but none of serious proportion. This county has a relatively high number of complaints against public institutions, such as schools, for smoke emissions.

In the City of Baltimore, heavy industry is concentrated around the harbor. The high concentration of industry results in high concentrations of pollution in the immediate vicinity of the most suspect sources. This zone is generally east and south of the commercial and residential areas so that northwest winds tend to disperse emissions in the direction of the bay. There are exceptions to this general statement in that certain plants are located at some distance from the main industrial zone. These are infrequently the cause of local episodes. Open burning at authorized dumps also creates problems. Although sources emitting particulates predominate, emissions of gases, vapors, and odors cause varying degrees of annoyance.

Considering the region as a whole, objections to conditions seem localized. Areas of complaints are most often not contiguous, and complaints allege a definite local source. Complaints are consistently directed against an obvious condition, the source of which is readily identifiable. It is, however, often difficult to determine whether continuing and increasing complaints against certain conditions are caused solely by lack of control of alleged sources or by an increase in public awareness of the air pollution levels present.

REFUSE DISPOSAL PRACTICES

At present, Anne Arundel, Howard, and Baltimore Countys provide residential trash and garbage collection by contract with private operators. The waste collected is buried at public or private landfills. Anne Arundel County utilizes private landfills, generally the property of the contract operators. Baltimore and Howard Countys own and operate landfills. Private landfills are also used in Baltimore County. The landfills are supervised for proper sanitary practice by the county health departments, with technical assistance from the State Department of Health. Only recently has supervision become effective. No county has, as yet, erected an incinerator.

Municipal service is provided for residential trash and garbage collection by the City of Baltimore. Some commercial and industrial collection is also provided by the city; however, many businesses and industries contract with private operators for waste removal. Disposal of the latter is to private landfills, public landfills, and to municipal incinerators. The city disposes of collected waste by incineration and burial of the ash and overload in public landfills. Open burning is discouraged, although certain special conditions, such as leaf burning and excessive overload, require exception to this policy. The magnitude of the leaf disposal problem has not yet permitted a practical substitute method. In general, there is little domestic backyard incineration in the region. The practice of installation of incinerators in shopping centers, large commercial establishments, and activities generating considerable amounts of bulky, combustible trash is becoming more common. The incinerators installed are usually well designed and constructed. Operators are, however, often indifferently trained and infrequently supervised. In consequence, nuisances often arise.

Instances of faulty operation of hospital and apartment house incinerators have been reported. Usually, these occurrences result from carelessness, minor breakdown, or overloading. Since most apartments are in the city, alternative methods of disposal are available at little extra cost. With the increase in solid combustible wastes resulting from current packaging methods, this problem will need more attention, especially since more apartment buildings are being erected in the counties.

STATUS OF CONTROL OF POLLUTION SOURCES

In the county areas, with only a few exceptions, very little contact work has been done with industries by governmental personnel on the subject of air pollution. Consequently, little is known about the controls effected in industrial plants in the counties. Certain sources such as schools, industries, and commercial operations are known to need control equipment as a result of investigations of complaints concerning smoke, dust, and odor emissions. Large industries, such as that at Sparrow's Point, are known to have spent much money on air pollution control equipment.

In Baltimore City, much more information is readily available on the status of control of various sources. The city's Division of Air Pollution Control has long been acquainted with the city's problem sources as a result of complaint handling, the smoke abatement program, and a plans review program for new construction or alterations of equipment that may cause emissions to the atmosphere. Several pyrometallurgical plants, dumps, and smelters are known to be heavy particulate emitters and in need of control. Chemical plants and dumps are major sources of odors. Most of the major coal and fuel oil heating and power plants do not have fly ash or particulate collection systems. All commercial size installations are, however, required to have smoke alarm systems when coal and/or No. 5 or 6 fuel oil are to be burned. Acid plants present the greatest problem in air pollution in that better control systems for oxides of sulfur, sulfuric acid, and oxides of nitrogen are needed. The venting of petroleum storage tanks is believed to contribute significantly to the area's air pollution problem. Municipal incinerators, being overloaded, do not burn garbage completely. This partially burned material, smoldering in ash storage piles, emits objectionable odors. Power plants, coke plants, the sewage treatment plant, fertilizer plants, rendering plants, and soap factories apparently maintain good control over their processes and emissions and do not cause large numbers of complaints.

One important function of a strong area-wide air resource management program would be to define through a detailed emissions inventory the sources of air pollution in the counties and the city. Such an emissions inventory would remove the "educated" guess work that now forms the foundation for what is known about the status of air pollution control.

Better controls on particulate emission sources are needed to reduce the excessive pollutant levels now found in residential, commercial, and industrial areas. As shown by Figure 8, median values to be used as goals might be 80 $\mu g/m^3$ for the residential areas, 100 mg/m^3 for the commercial areas, and 135 $\mu gm/^3$ for the industrial areas.[15] This set of objectives is the least stringent of four sets of regional objectives adopted by New York State. The residential levels measured now meet this objective. To attain these goals in the commercial and industrial areas assuming no increase in emissions will occur would require a 33 percent reduction and a 47 percent reduction, respectively, of suspended particulate emissions. Figure 8 also shows that high levels of suspended particulate concentration occur more frequently than is specified by the objectives cited above. These objectives state that concentrations equal to or greater than 120 $\mu g/m^3$ for residential areas, 150 $\mu g/m^3$ for commercial areas, and 200 $\mu g/m^3$ for industrial areas are not to occur more than 16 percent of the time. This means that a greater degree of control would be needed during high pollution periods than during low pollution periods to meet the objectives. The degrees of control necessary to lower high pollution levels to those specified above assuming no increase in emissions will occur would be 14 percent for residential areas, 37 percent for commercial areas, and 53 percent for industrial areas. These percentages of control may seem low when it is considered that any practical means of control will obtain greater than 70 percent control for most sources. When it is pointed out that many sources, such as residential space heaters, are not controllable except by proper maintenance, and that other sources presently use control equipment these percentages of reduction seem realistic and possibly difficult to achieve. It must be kept in mind that the number of sources of air pollution are not going to decrease or remain constant. A glance at the population trends (Figure 4), automobile registration trends (Figure 19), fuel use trends and so forth, makes it obvious that more and more sources will be pouring more and more pollutants into the metropolitan atmosphere. Excessively high peak values of suspended particulate now occur in all three areas. "Excessively high" can be thought of as three times the recommended median values.

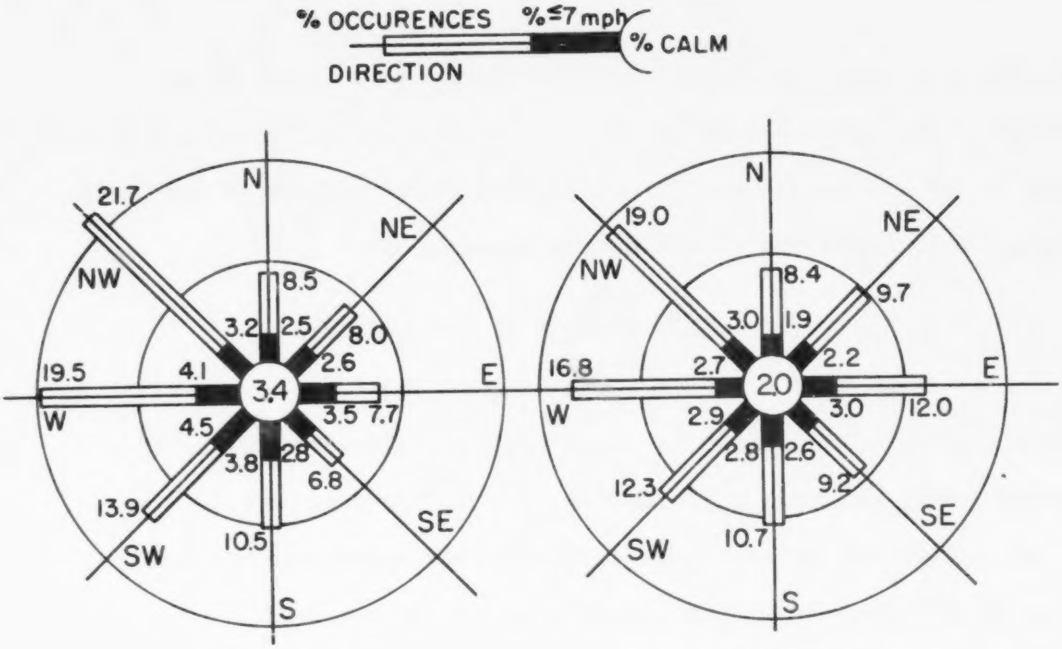
In the past, significant reductions in particulate emissions resulted from (1) enforcement of the smoke abatement ordinance, (2) use of district steam heating in the downtown area, (3) control of industrial emissions, and (4) the trend from solid to liquid and gas fuels, especially in residences. Sulfur dioxide emissions were also greatly reduced by the vigorous action of city officials and the cooperative actions of industry. In the future, rapid growth in population accompanied by industrial expansion will cause increased emissions of all pollutants. It has been estimated that by 1980 increased fuel usage will increase sulfur dioxide emissions by 50 percent provided the sulfur content of coal is reduced to 2 percent.[24] Only with greater than 50 percent control of carbon monoxide emissions from automobiles will this pollutant be kept at its present levels. Nitrogen dioxide emissions will double by 1980 primarily as a result of an enormous increase in the number of automobiles used. To prevent deterioration of the ambient air quality and to protect the welfare of the public, better control than now exists must be accomplished.

METEOROLOGICAL ASPECTS OF AIR POLLUTION

As recorded at Friendship International Airport, average wind velocities are high (from 8 to 13 mph) and the winds are most often northwesterly, carrying air pollution over the bay away from populated areas.[8] Over the bay area, wind directions and velocities may vary considerably from the pattern recorded at the airport because of the effect of the large body of water.

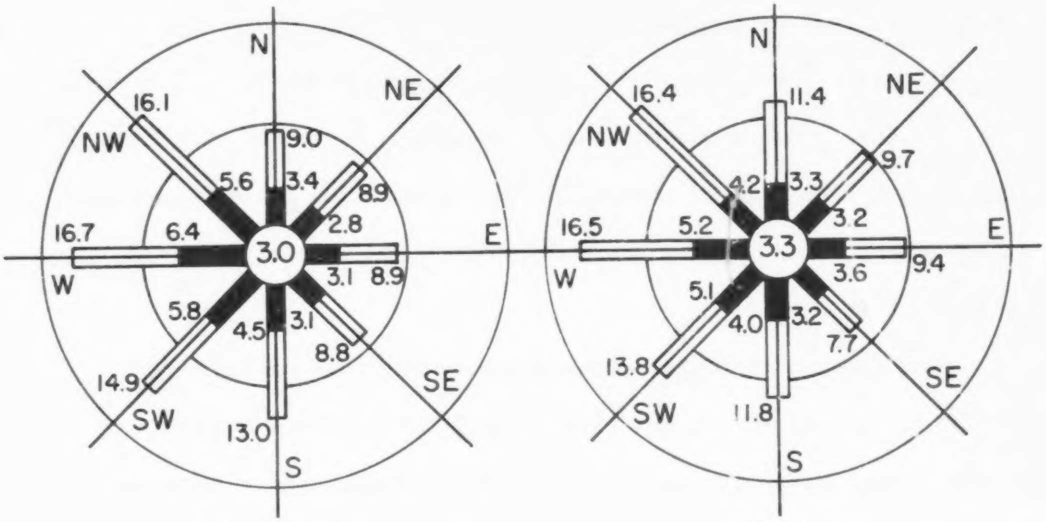
It has often been stated by those opposing air pollution control and generally conceded by those supporting air pollution control that since winds are predominantly northwesterly, most of the air pollutants emitted are carried over the bay away from residential areas. This is not true. Such winds occur only about 32 percent of the time. This means that more than 65 percent of the time pollution emitted within the industrialized bay area is carried into residential areas in and around the city.

High pollution incidents often occur during calm periods or during periods of low wind speed (less than 7 mph). These periods of low wind speed occur 32 percent of the time (Figure 20). Over one-fourth of these high pollution potential winds carry air pollution from the industrialized bay area into Dundalk and the area of Baltimore



WINTER
AVG. 10.9 mph
≤ 7 mph : 30.4%

SPRING
AVG. 11.8 mph
≤ 7 mph : 23.1%



SUMMER
AVG. 9.0 mph
≤ 7 mph : 37.7%

FALL
AVG. 9.7 mph
≤ 7 mph : 35.1%

Figure 20. Seasonal wind roses.

nearby. Examination of the wind roses indicates that the dominant frequency of occurrence for low wind speeds is southwesterly instead of northwesterly. For these periods of high pollution potential, northwesterly winds occur only 25 percent of the time. Therefore, three out of every four of these high pollution potential winds carry pollutants from the bay area into residential areas.

Also related to high pollution incidents are periods of inversion (stable air layer conditions). Strong inversions are often indicated by low wind speeds and little or no cloud cover. Such data are shown in Table 16.[16] Inversions occur most frequently in the summer and fall. As can be expected, most inversions occur during the night when air near the ground has cooled faster than the upper air.

It has been observed that major air pollution episodes are usually related to the incidence of stagnating anticyclones in or near urban areas. Such anticyclones are characterized by very low surface wind speeds and linger over areas for 4 days or more, causing an accumulation of pollutants. Analysis of meteorological data from 1936 to 1960 for the eastern United States by Korshover has defined the occurrence of these stagnating anticyclones.[17] Baltimore lies near the outer edge of the pattern of occurrence of such anticyclones. To the north, anticyclones occur less frequently; to the south, they occur more often. As shown in Table 17, major stagnation cases (7 or more days) occur very seldom in Baltimore (about once every 12 years). Stagnation cases of 4 or more days occur about twice a year and are most likely to occur during August, September, or October.

Table 17. STAGNATING ANTICYCLONES OVER BALTIMORE[a]

Monthly occurrences, 4 or more days

January	0	July	2
February	0	August	9
March	0	September	10
April	1	October	9
May	3	November	2
June	3	December	2

Total occurrences, 4 or more days: 40
Total number of stagnation days: 200
Total number of 7 or more day periods: 2

[a] Reference 17.

Table 18. HEATING DEGREE-DAYS, AVERAGE 1950 - 1963[a]

Month	Friendship Airport	Balt. Md.	Month	Friendship Airport	Balt. Md.
July	0	0	January	980	897
August	1	0	February	817	749
September	57	30	March	700	626
October	252	170	April	326	266
November	589	489	May	119	76
December	931	834	June	12	5
			Average yearly total	4775	4139

[a] References 18 and 19.

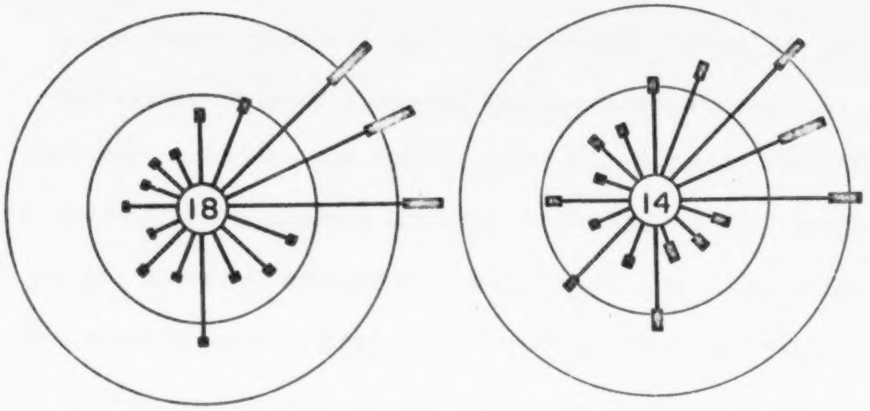
Table 19. COMPLAINTS, 1963 AND 1964

Source	Area					
	Baltimore City	Anne Arundel County	Baltimore County	Howard County	State	Total
Municipal	88	4	50	0	3	145
Domestic	72	0	5	2	0	79
Commerical	424	0	12	0	4	440
Industrial	310	4	16	8	8	346
Agricultural	0	4	1	0	1	6
Motor vehicles	17	0	10	0	5	32
Other or none named	115	8	6	0	1	130
Total	1026	20	100	10	22	1178

Since August 1960, high air pollution potential forecasts have been made for the eastern United States, and have been issued to requesting agencies and local weather bureaus. These forecasts have successfully predicted the occurrence of high air pollution potential periods. These high air pollution potential periods are defined as the existence of meteorological conditions over an area favorable for the accumulation of air pollutants for a period greater than 36 hours. Most of the forecasts issued have, with very few exceptions, occurred in the summer and fall. These forecasts can be used by local control agencies to intensify air monitoring during high pollution episodes, to evaluate the need for special rules and regulations that may be needed, and to apply more rigid controls to large sources of air pollution. Large industries alerted to such situations can take special steps to minimize their emissions. Through publicity and special policing, activities such as leaf burning and other open burning can be suspended or reduced to a minimum.

Heating degree-days indicate the amount of pollution attributable to space-heating requirements. This is shown by month in Table 18.[18,19] Especially notable in these data is the difference between the heating requirements for the city compared to those for areas beyond the heat island influence of the city.

Figure 21 reveals the bay area pollution's effect on its surroundings.[20] Wind roses are shown for periods of restricted ceiling and visibility for



CEILING BELOW 500 ft
AND/OR VISIBILITY BELOW 1 mi.

CEILING BELOW 1000 ft
AND/OR VISIBILITY BELOW 3 mi.

PERIOD OF RECORD: AUG. 1950 - MAR. 1955 INCLUSIVE.

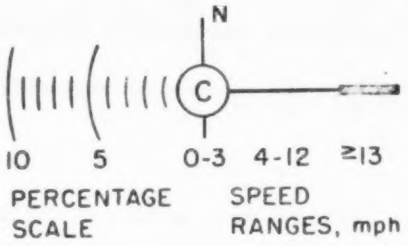


Figure 21. Windroses for restricted ceiling and visibility

the airport, which lies southwest of the industrialized bay area. About 37 percent of the occurrences of restricted ceiling and visibility occur when the wind is from the northeast quadrant where the industrial bay area lies. This becomes even more significant when it is noted from Figure 20 that winds from this quadrant occur 19 percent of the year, yet they account for 37 percent of the occurrences of restricted ceiling and visibility.

PAST STUDIES

In 1928 and 1929 the U.S. Public Health Service conducted a study to determine the ultraviolet light reduction caused by particulates in the atmosphere. At that time, it was estimated that dustfall averaged 120 tons per square mile per month. This is 2.5 to 4 times as high as present industrial area levels, 4 to 5 times present commercial area levels, and 6 to 10 times present residential area levels.

In 1950 and 1951, the Maryland Commission on Noxious Fumes directed a study that concluded:

> "Maryland has a definite problem of air pollution," "pollution of the air is most critical in sections of Baltimore City and areas adjacent to it," and "pollution knows no political boundary and its control should be initiated at a State level with the cooperation of the counties and municipalities."[21]

Since this report, the State has organized an air pollution control authority in the State Board of Health and Mental Hygiene that is advised by the State Air Pollution Control Council. The State Department of Health is the administrative agency responsible for discharging technical duties assigned to the Board.

EFFECTS OF POLLUTION IN THE AREA

Adverse effects of air pollution in the area on public health have never been clearly demonstrated. It is anticipated that the study directed by Dr. Spicer will produce correlations between various measurements of air pollutants and the impairment of respiratory functions.

Air pollution has caused numerous nuisances, some of which have been serious. These include plant damage, property damage, soiling of clothing, reduced visibility, eye and throat irritation, and odors.

Complaints on air pollution in city health department files date back to 1916. These became more numerous as industrial facilities expanded and the industrial area grew. From 1954 to 1960, a decrease in complaints was noted, but a rise has been noted since then. The majority of the plants against which complaints have been registered are located within the area lying between Baltimore Street and the harbor line from Curtis Bay to Sparrow Point. The tabulation in Table 19 shows complaints in the counties are primarily directed against municipal and industrial sources. Commercial and industrial sources are the major offenders in the city. Commercial sources and motor vehicles in the counties and municipal and domestic sources in the city are of secondary concern.

Special problems also occur, such as the decay of sea lettuce, Ulva lactuca, a green algae that poses a problem in Anne Arundel County along the shoreline. This algae often grows in quantity where water pollution, salt water, and fresh water are present together. Anaerobic decomposition of large buildups of dead algae result in the emission of disagreeable quantities of hydrogen sulfide.

Newspaper coverage of the effects of air pollution in Baltimore has documented such major incidents as tree and plant damage; offensive odors, affecting many people; heavy soot falls, causing soiling of an abnormal degree; large dump fires; hosiery damage; automobile paint damage; and offensive odors and paint damage caused by natural decomposition of sea lettuce.

GOVERNMENTAL ACTIVITY IN AIR POLLUTION CONTROL AND RELATED FIELDS

Governmental agencies in the Baltimore metropolitan area are becoming increasingly concerned about air pollution. From this concern, a cooperative spirit has been generated among the State and local health departments. The city has an active control program and is willing, in an advisory capacity, to help the counties develop air pollution control programs.

In Anne Arundel County, air pollution control provisions are founded under zoning regulations enforceable by the County Health Department. The zoning regulations on odor and smoke are good; however, the regulations on the emission of particulate matter are weak. Plans and specifications are required for review and approval by the County Health Department prior to any construction in the county. The County Health Department receives and investigates complaints on air pollution. To improve the effectiveness of regulations to control air pollution and the health department's investigational work, an air pollution control ordinance that would place control authority officially under the health department should be adopted. At present, the Environmental Health Division of the County Health Department has the services of a Public Health Engineer and two qualified Sanitarians, who have operated three air pollutant sampling stations in the county for 2 years.

Baltimore County is working toward the development of an air resource management program. The Baltimore County Air Pollution Study Committee, appointed in July 1963 by the County Executive, concluded that (1) the people of the county are not interested in any general air pollution problem, (2) specific nuisances are a definite problem to the people, with municipal sources cited as well as industrial ones; and, (3) in the past, the county government has not provided adequate service in satisfying complaints. It has been recognized that all air pollution cannot be eliminated and enforced. To this end, a complete catalog of pollutants emitted, air sampling to determine present levels of pollution in Baltimore County, and information on permissible limits of various pollutants in the atmosphere are needed. It has been recommended that responsibility for the investigation and control of nuisances caused by air pollution be placed in the health department's jurisdiction instead of being divided among the health, fire, building inspection, and permits and licenses departments. Actions have been taken by the county to reduce the emission of excessive smoke and pollutants from county buildings and schools. The County Department of Planning and Zoning considers the effects of air pollution in its planning activities and zoning recommendations. The health department has primary responsibility for the investigation and control of air pollution through its Division of Industrial Hygiene under the Section of Environmental Health. The County Executive and the Air Pollution Study Committee have led in the establishment of the county's policy on air pollution and will probably support the health department in any cooperative efforts to define the metropolitan area's air pollution problems.

As stated before, the City Health Department has competent, well-qualified air pollution control personnel. It administers a plans review program, a smoke abatement program, and a complaint investigation and nuisance evaluation service. A large air monitoring network is also maintained. Health department officials are sincerely interested in developments in county control and are willingly offering assistance and direction through cooperative program work. This agency has a fairly thorough knowledge of air pollution sources within its jurisdiction and has been effective in control work.

Howard County has very few air pollution problems, since it is largely rural. The County Health Department's primary functions concerning air pollution are to answer complaints and enforce any applicable State laws. No county authority on air pollution has been granted by the State to Howard County, and, at present, the State has no emission limitations or prohibitions except a general nuisance clause on air pollution. County Health Department officials are interested in any cooperative activities that may occur in the metropolitan area and wish to be included, even though their participation may be small. No large problems are anticipated, but a preventative attitude is believed to be an excellent approach toward maintaining the present air quality.

The newspaper media has been highly critical of the State Air Pollution Control Council indicating the Council has done little constructive work in the field of air pollution control since its formation. The Council has recently produced a report in which goals listed for the State of Maryland Air Quality Control Program have merit. The nonindustrial representative on the Council has stated that industrial representatives have stifled the constructive efforts of other members of the Council.[25]

The State program is directed primarily toward technical assistance in the definition of local problems and the maintenance of a statewide air pollutant sampling network. The present State sampling program has been developed to evaluate several pollutants in different areas of the State so that air quality goals can be promulgated for various land uses. When these are accepted, local agencies will be assisted in establishing a program to achieve the air quality goals. Metropolitan areas will probably require more stringent control regulations than those administered by the State.

The State does not expect to preempt any powers of political subdivisions. Indeed each city and county is encouraged to adopt rules and regulations consistent with the severity of the problem for control of its local condition. This type of control has been established in the City of Baltimore and is being considered by several of the counties of greatest population density. Except for Baltimore, source control is usually handled under general nuisance provisions rather than general regulations for classes of sources. When source operators refuse to cooperate, control based on the general nuisance provision is not very successful.

Zoning authorities are considering air pollution as one of the factors affecting land use. In only a few cases has this factor seemed critical, but in those cases the evaluation was given considerable attention.

Planning agencies are becoming increasingly aware of the need for coordination of controls. Communities in the vicinity of the District of Columbia have organized to develop a cohesive plan to be applied throughout the metropolitan Washington area. Both State and local governments are included in this organization. A similar organization is being formed in the metropolitan Baltimore area. Here the emphasis is placed primarily on air pollution, whereas in Washington the problems considered cover a broader field. In both cases, action is still in the planning stage.

PUBLIC HEALTH OFFICIAL QUESTIONNAIRE

The results of a public health official questionnaire answered by representatives of the local and State departments of health concerned with air pollution in the metropolitan Baltimore area are tabulated in Table 20.

The section on "Complaints" shows that the health departments are generally contacted by the public on air pollution problems. In the counties, complaints occur most often in the summer, which has the most favorable meteorological conditions for pollutant accumulation. In the city, complaints occur most often in the spring. The number of complaints is increasing in the counties and is constant in the city although Figure 16 shows a slight increase recently. No agreement is found on what season has the most air pollution, but public health officials believe air pollution problems are increasing.

Under "Problem Locations" on the questionnaire, the need for cooperative action is demonstrated by the fact that every health officer stated that problem sources affecting each health department's jurisdictional area are located both inside and outside of that area. Major contributors of air pollution named were motor vehicles, industries, and municipal sources. Industries were generally named as the major pollution contributors outside each health department's jurisdictional area.

Table 20. **PUBLIC HEALTH OFFICIAL QUESTIONNAIRE**

		Baltimore	Baltimore County	Anne Arundel County	Howard County	State
Complaints	Normally contacted by public on air pollution	Y	Y	Y	Y	Y
	Others might be contacted	Y	Y	N	Y	Y
	Complaints (2 years)	1026	100	20	10	22
	Most complaints	Spring	Summer	Summer Fall	Summer	?
	Complaint trend	Same	Up	Up	Up	Same
Air Quality	Air pollution problem in area	Y	Y	Y	Y	Y
	Worst air pollution season	Spring	Fall	Summer	Spring Summer	Winter
	Air pollution problem trend	Down dust Up oxidant	Up	Up	Up	Up
Problem Locations	Problem sources in jurisdiction	Y	Y	Y	Y	Y
	Major or moderate contribution	Motor vehicles Industry Municipal	Motor vehicles Industry	Motor vehicles Industry Municipal	Motor vehicles Industry	Motor vehicles Residential Commercial
	Problem sources outside jurisdiction	Y	Y	Y	Y	Y
	Major or moderate contribution	Industry Motor vehicles	All except agriculture	Industry	Industry Commercial	Municipal
Air Pollution Effects	Air pollution					
	Smells bad	Y	Y	Y	N	Y
	Irritates eyes, nose	N	Y	Y	N	Y
	Soils or damages property	Y	Y*	Y	Y*	Y*
	Makes area dirty	N	Y	N	Y	Y
	Gives bad reputation	Y	N	N	Y	N
	Reduces valuation	N	N	N	Y	N
	Causes vegetation damage	Y	N	N	N	N
	Reduces visibility	Y	N	Y	N	N
Air Pollution Laws	Laws in area on air pollution	Y	Y	N	N	Y
	Zoning provisions	N	Y	Y	N	Y
	Fire regulations	N	Y	Y	N	Y
	Local laws adequate	Partly	N	N	N	N
	State laws adequate	?	N	N	N	N
Air Pollution Control Program Support	Money budgeted for air pollution control by government	$45,000	None	$5,000	None	?
	Public and political support for air pollution program	Y	Y	Y	Y	Y
	Amount public and politics may support	5-10¢	?	5¢	5¢	10¢
	Community group support of air pollution control action	Y	Y	Y	N	Y
	Attitudes					
	Public	Minor	Moderate	Moderate	?	Moderate
	Elected	Moderate	Moderate	Minor	Minor	Moderate
	Doctors	Moderate	Moderate	?	Moderate	Moderate
	Industry	Moderate	Minor	?	Minor	Minor
	Civic leaders	Moderate	Moderate	?	?	Major

Y = yes, N = no

* Most important effect of air pollution.

In "Air Pollution Effects" the health officials decided that air pollution in the group's opinion smells bad; irritates the eyes, nose, and throat; soils or damages property; and makes the area dirty. Soiling and property damage is the most objectionable characteristic of the area's air pollution to these officials.

Present local and State air pollution control laws are considered inadequate. At present very little money is spent by local governments to control air pollution, less than $0.03 per person per year. Public and political support for air pollution control program expenditures does exist. The support will probably sustain appropriations of at least 5 to 10 cents per person per capita. It is interesting to note that the monies required to set up and operate the proposed comprehensive study will be very near this range if Federal support under the Clean Air Act is obtained.

PROPOSAL FOR A COMPREHENSIVE AREA-WIDE STUDY

Air pollution is no respecter of political boundaries. Today air pollution problems do exist throughout the metropolitan Baltimore area. With the rapid increases in population, automobile registrations, and industry anticipated in the near future, air pollutant emissions will undoubtedly increase causing a corresponding increase in problems if controls are not installed on emission sources.

Even though industry is generally cooperative and conscientious in controlling its emissions, the lack of a good governmental control agency and control law usually results in the recurrence of serious problems. The unscrupulous or ill-advised individual who cares little about the inconvenience his emissions cause his neighbor always seems to be present.

Municipal and other governmental operations are also often cited as major offenders.

In the past, advances in technology and economics have mitigated and, in some cases, erased air pollution problems. An important example is the radical change in fuel use over the past 30 to 40 years. An average dustfall level of 120 tons per square mile per month in 1928 was cited in the literature. Today levels seldom reach 60 tons per square mile per month, and these levels occur only in or near heavy industrial areas. This improvement in dustfall conditions undoubtedly can be attributed to improved combustion practices and the change from coal to gas or oil in small combustion units. Other pollutants that formerly were emitted as waste are collected today as by-product materials. In the future, it is hoped that a great reduction in automobile emissions will result from improvements in engine design.

Even with such improvements alleviating certain pollutant emissions, it is pure folly for anyone to expect air pollution problems to go away or solve themselves without centralized direction. Although fuel changes and other developments have reduced certain types of pollution, such as particulate matter and sulfur dioxide, urbanization and diversified technology tends to concentrate emissions, expose the majority of the people to these emissions, and generate many air pollutants hitherto unknown to man. In addition, the social attitude concerning air pollution is different from that 20 to 50 years ago. In the past, air pollution was associated with industry and accepted as necessary. Today with a consumer-based economy and knowledge of controls available, uncontrolled air pollution of great magnitude is not acceptable.

For the most efficient direction of control efforts in Baltimore, the governments concerned must have an adequate definition of air pollution emissions, levels of air pollution that exist, and the effects attributable to certain air pollution levels. Obtaining such information requires time, money, and manpower. With the varied resources available to the different governmental agencies involved, optimum results can not be expected if each works separately on the area for which it is responsible politically.

The most efficient approach to solving area-wide problems for a metropolitan area such as Baltimore is a regional agency. This may be the ultimate answer for the urbanized society, but today attempts to organize such an agency immediately are confronted with political and financial problems. Most local governments are reluctant to relinquish any of their police powers to autonomous agencies. In addition, a formula for obtaining equitable financing for a regional agency is difficult to derive to the satisfaction of the various governments involved.

The best approach for organizing and administering an area-wide survey followed by an area-wide air resource management program seems to be the establishment of a cooperative committee consisting of the heads of the administrative agencies concerned. At present, the cooperating agencies include the Baltimore, Baltimore County, Anne Arundel County, and Howard County Health Departments and the State Department of Health. The cooperative committee initially should include the following individuals or their designated representatives:

The Director of the Bureau of Industrial Hygiene, Baltimore Health Department

The Director of the Section of Environmental Health, Baltimore County Health Department

The Director of Environmental Health of the Anne Arundel County Health Department

The Public Health Sanitarian of the Howard County Health Department

The Chief of the Air Quality Section, Maryland State Department of Health

The purpose of this committee would be to:

1. Establish an area-wide air sampling network plan.
2. Produce a cooperative project agreement, outlining the project's organization and the resources to be supplied by each cooperating agency.
3. Prepare Federal grant applications and direct the use of monies and manpower available for the survey's operation.
4. Establish standard procedures, both administrative and operational (map grids, complaint and other forms, emission inventory and sampling methods).
5. Create and initiate through the survey project a workable plan for obtaining, storing, and using emission inventory data.
6. Coordinate work done by the cooperating agencies on air pollution control.
7. Obtain popular and political support for actions taken on air pollution through news releases and direct liaison.
8. Resolve interjurisdictional control problems.
9. Aid cooperating agencies in the development of practical, strong air pollution control ordinances and programs.

10. Advise other agencies on the progress of work done by the committee and any policy decisions made. Such agencies would include industrial associations; professional societies, such as the American Medical Association; urban redevelopment commissions; and any other governmental or nongovernmental organizations concerned with air pollution.

The committee would require secretarial services for transcribing decisions made and work done on various problems. Reproduction services would also be needed, and the services of an information and education specialist would be valuable. Such minor requirements can probably be obtained voluntarily from the agencies represented. Since one of the committee's purposes is to produce uniform data collection procedures, a single source from which such forms can be obtained should be designated.

SELECTION OF A MAP GRID SYSTEM

Any unit of data that has value when attached to the location to which it refers can be easily identified by the coordinates of a standard map grid system. Coordinate identifications also make possible the electronic production of valuable comparisons of tabulated data. Such a grid system is described in "Memorandum of Information and Instruction No. 1, Maps and Map Grid Systems" by the Technical Assistance Branch, Division of Air Pollution, Department of Health, Education, and Welfare. Coding of all data by the grid system is the simplest, clearest method for locating information geographically. With a six-digit number, a piece of data can be located on a grid map within 1,500 feet of its exact location immediately, without prior knowledge of the metropolitan area.

On U.S. Geological Survey maps of the metropolitan Baltimore area, both the Universal Transverse Mercator grid and the Maryland coordinate systems are laid out. The Universal Transverse Mercator system uses 1,000-meter grids. The Maryland coordinate system is oriented along a true north direction whereas the Mercator system is oriented vertically, a little over 1 degree counterclockwise from true north.

Table 21 summarizes the U.S. Geological Survey maps covering the metropolitan area.

Although the Universal Transverse Mercator grid system has the disadvantages of not being oriented in a true north direction and of being in metric units, it is recommended because of its applicability all over the world and because it is serving as a base for a growing body of information.

USE OF COMPUTER SERVICES

Any emission inventory or comprehensive air monitoring network produces large amounts of data that are difficult to reduce to meaningful form. Electronic handling presents the best solution for this tedious, time-consuming job and will produce more accurate results than manual reduction. Correlations of different sets of data are also best accomplished by the computer.

Of course, the success of any computerized operation depends upon the design of the computer program. Therefore, the services of a good statistician would be needed. The assigning of grid coordinates to all data collected is essential for the operation of a complete, electronic

Table 21. U.S GEOLOGICAL SURVEY MAPS[a]

7½-minute maps	15-minute maps	Baltimore	Baltimore County	Anne Arundel County	Howard County	Metropolitan Area
	Parkton		x			
New Freedom			x			
Norrisville			x			
Hereford			x			
Phoenix			x			
	Westminster		x			
Hampstead			x			
Lineboro			x			
	Rockville				x	
Sandy Spring					x	
	Mt. Airy				x	
Damascus					x	
Woodbine					x	
	Ellicott		x		x	x
Sykesville					x	
Ellicott City			x		x	x
Finksburg			x			
Reisterstown			x			x
	Baltimore	x	x			x
Baltimore East		x				x
Baltimore West		x				x
Cockeysville						x
Towson						x
	Gunpowder		x			x
Middle River			x			x
Gunpowder Neck			x			
White Marsh			x			x
Edgewood			x			
	Laurel			x	x	x
Laurel				x	x	
Savage				x	x	x
Clarksville					x	
	Relay	x	x	x	x	x
Round Bay				x		x
Odenton				x		x
Curtis Bay		x	x	x		x
Relay		x	x	x	x	x
	North Point		x	x		x
Gibson Island				x		
Sparrows Point			x	x		x
West River				x		
Bristol				x		
Davidsonville				x		
South River				x		
Annapolis				x		
Approximate grid range						
Maryland (1000 ft)						
E - W		880 - 975	830 - 980	840 - 975	750 - 885	820 - 980
S - N		495 - 545	490 - 690	320 - 510	460 - 560	450 - 620
Mercator (1000 meters)						
E - W		350 - 380	340 - 390	340 - 380	310 - 360	340 - 3800
S - N		4330 - 4360	4330 - 4400	4290 - 4340	4320 - 4360	4330 - 4370

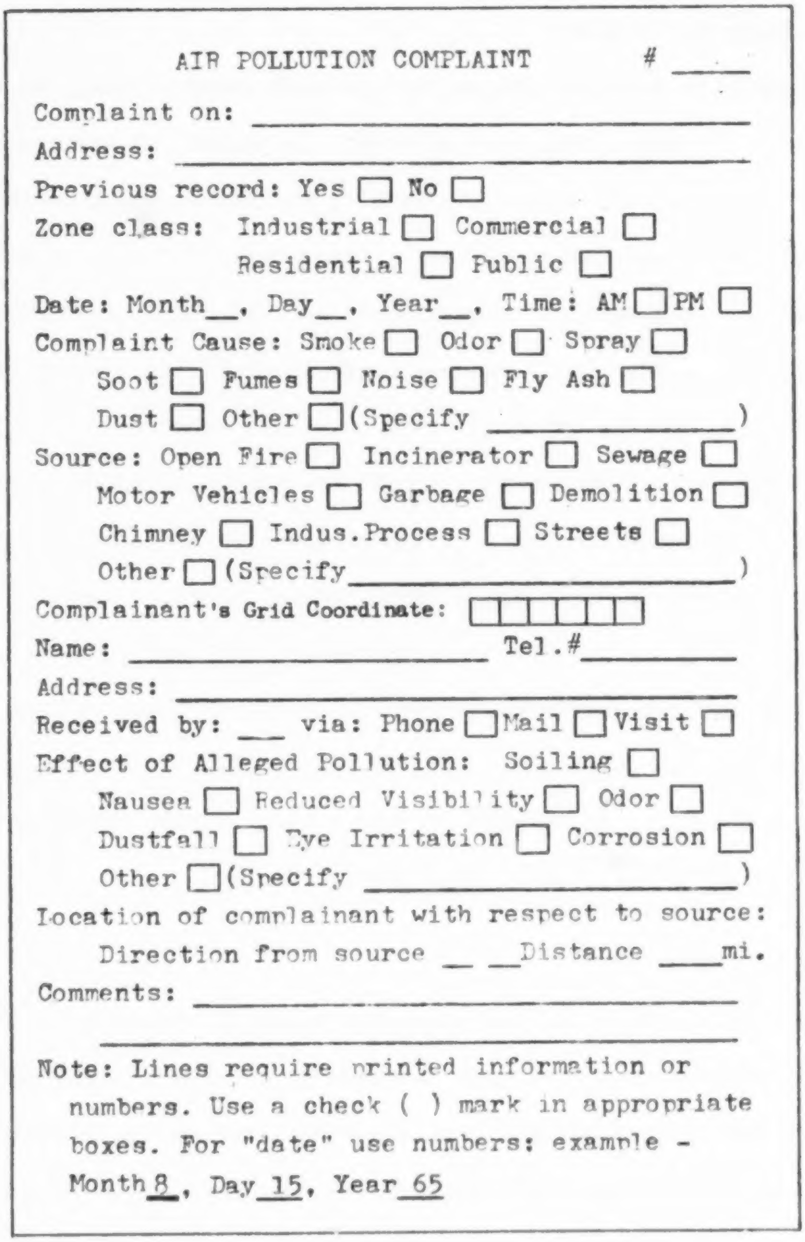
[a] The Washington, NJ 18-4, and the Baltimore, NJ 18-1, 1:250,000 scale maps also cover the area concerned and have the Maryland coordinate and Mercator grid systems on them.

data processing program. Also the forms used and procedures followed for recording data are important. Discussions of the various aspects of electronic data processing for air pollution data are included in "Memorandums of Information and Instruction, Numbers 2, 7, 9, 10, and 16," St. Louis Study, Technical Assistance Branch, and "Choosing an Aerometric Data System" by Ralph I. Larsen, Field Studies Branch, both of the Division of Air Pollution, Public Health Service, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio.

COMPLAINT HANDLING

At present, air pollution complaints in the Baltimore metropolitan area are recorded on a nuisance form that gathers little specific information from the complainant. Health departments often do not separate different types of complaints, and specific information is difficult to obtain from past records. Baltimore handles over 500 air pollution complaints a year, and has some difficulty in obtaining a simple breakdown of the sources (see Table 19) of emissions causing complaints, although annual reports do give a breakdown of complaints by pollutant class. The breakdown of complaints received by the counties and the State on air pollution in Table 19 is based more on estimates than on reference to complaint files.

It would be very helpful in obtaining a reliable, more complete record of complaints if a complaint form with useful information noted on it in such a way that any secretary could easily take the data from a complainant was adopted. An example of such a form is shown in Figure 22. The back of the data form can be used for the inspector's report, including name of the source, source owner, source address, person interviewed,



AIR POLLUTION COMPLAINT # ____

Complaint on: ______________________________

Address: __________________________________

Previous record: Yes ☐ No ☐

Zone class: Industrial ☐ Commercial ☐
Residential ☐ Public ☐

Date: Month__, Day__, Year__, Time: AM ☐ PM ☐

Complaint Cause: Smoke ☐ Odor ☐ Spray ☐
Soot ☐ Fumes ☐ Noise ☐ Fly Ash ☐
Dust ☐ Other ☐ (Specify ______________)

Source: Open Fire ☐ Incinerator ☐ Sewage ☐
Motor Vehicles ☐ Garbage ☐ Demolition ☐
Chimney ☐ Indus.Process ☐ Streets ☐
Other ☐ (Specify ______________________)

Complainant's Grid Coordinate: ☐☐☐☐☐☐

Name: ______________________ Tel.#_________

Address: __________________________________

Received by: ___ via: Phone ☐ Mail ☐ Visit ☐

Effect of Alleged Pollution: Soiling ☐
Nausea ☐ Reduced Visibility ☐ Odor ☐
Dustfall ☐ Eye Irritation ☐ Corrosion ☐
Other ☐ (Specify ______________________)

Location of complainant with respect to source:
Direction from source __ __Distance ____mi.

Comments: _________________________________

____

Note: Lines require printed information or numbers. Use a check ( ) mark in appropriate boxes. For "date" use numbers: example - Month 8 , Day 15, Year 65

Figure 22. Air pollution complaint form.

equipment producing air pollution, conditions found, action taken, dates, and the inspector's name.

Complaint handling procedures now used would probably be changed very little if such a form were adopted. In general, a secretary would receive the complaint, record the data in duplicate, and give the original record to the investigating officer. After the completion of the complaint investigation, the original record would be returned to the office, the office copy discarded (this copy was kept to avoid the loss of records in the field), and the original filed by street address.

A very effective means by which the complaint information can be presented is through the use of a map of the area of jurisdiction. With this map fastened to a pin board, each complaint can be located with a colored pin as the complaints are reported. Different colored pins can be used to designate different types of complaints (odor, smoke, dustfall, etc.). Such a map graphically illustrates problem areas and help pinpoint sources more easily, especially if major known sources are also located on the map and meteorological data are available.

EMISSION INVENTORY

A properly directed and conducted emission inventory is an important part of an air resource management program. A good emission inventory will define the pollutants emitted, the amount of each pollutant emitted, where pollutants are emitted, and the time and conditions of emission. Such information can be used to evaluate an air quality monitoring network, including such elements as the sampling and analysis techniques used, the location of samplers, and the sampling schedule.

With a knowledge of what is being emitted from various sources, the effects of air pollution control regulations on the ambient air quality and the community's economy can be accurately gaged. In addition, needed regulations that would result in the greatest reduction of ambient pollution at the smallest economic cost to the community can be more easily determined.

The pollutant sources of an area can be divided into five classes: industrial, transportational, residential, commercial, and power generation. Difficulty is often encountered in trying to place certain special sources in a class. This problem can be simplified by thinking of the classes in a zoning sense or as a gradation of source dirtiness. Thus, a greenhouse operation should be classed as commercial since it commits few emissions acts other than space heating during cold periods.

Emission factors for estimating the amounts of pollutants emitted from various sources can be obtained from the Technical Assistance Branch, Division of Air Pollution, Public Health Service, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio. Aid may also be obtained from the Technical Assistance Branch in developing adequate emission inventory forms for collecting the emission data.

Industrial Class

The Chambers of Commerce and any industrial associations in the area can give valuable assistance in gathering information on the industrial class. Most Chambers of Commerce have lists of the industries in their area and also have information on the number of persons employed and products produced by each industry.

Included in the industrial class are mining and quarrying, manufacturing, construction, municipal incineration, and sewage treatment. Industrial emissions include emissions from fuel burned, processes, and trash destroyed on industrial property.

Industrial survey forms that can be used to gather pertinent information from the numerous types of industries that will be encountered should be adopted. If possible, the data forms should be designed for electronic handling of data.

In a typical emission inventory, two industrial survey forms and an introductory letter are sent to all industries. One form is to be returned to the health department and the other is to be retained by the industry. As the questionnaires are returned, they are checked for completeness, and their status is recorded on survey status forms. If a questionnaire is incomplete, a phone call is usually very effective in obtaining emission information. Two to four weeks after the questionnaires have been sent, the industries are divided into categories, and phone calls are made to industrial representatives who have not returned the questionnaires,urging them to cooperate in the study. It is advisable to concentrate on major categories first, visiting those industries on which data are lacking and obtaining as complete a record as possible. Personal inspections of important sources or potential sources are very valuable for verifying or gathering information, telling the management about control efforts being made in the area, and becoming acquainted with the management and industrial processes.

Transportation Class

The transportation class of sources is the most difficult to analyze meaningfully. Because of the mobility of automobiles and the wide variability of emissions from automobile motors, assessing these emissions for areas smaller than a city or county is very difficult. It may even be difficult to determine the emissions from motor vehicles in the entire metropolitan area because of the large number of transient vehicles using the area's highways. Pollutants emitted when service station tanks and automobile tanks are filled can be determined.

Emission factors are available for calculating the amounts of pollutants emitted by aircraft landing and taking off at airports. Emissions from ships entering and leaving port facilities should be determined. The amounts of fuel used in railroad switching yards and by through trains should be estimated.

Residential Class

In the residential class are included all residences and apartments. Emissions for this class are primarily from space heating units, although some open burning and incineration does occur. In the fall, open burning of leaves is a major source of air pollution.

Fuel usage by the public is calculated from housing census figures, the number of degree-days per year, and factors derived from the estimated percent efficiency of household units and the fuel's Btu content. Water-heating and cooking fuel is considered negligible.

Commercial Class

The commercial class of sources is practically a catch-all category.

In it are placed office buildings; governmental buildings; institutions, including schools, hospitals, and churches; wholesale and retail trade; finance and insurance offices; services; hotels; motels; and shopping centers. Many of these establishments maintain incinerators that should not be overlooked.

A listing of wholesalers is usually available from the Chamber of Commerce.

Emissions include those from space heating and open burning or incinerating of trash on the commercial property. A few process emissions do occur in some services and institutions in this class. Dry cleaning, printing, painting, and welding are a few such examples.

Power Generation Class

Because of the large amounts of fuel consumed in power generating operations and their special characteristics, municipal and district power and steam generation plants are separated into another class. Information on emissions from these plants is usually easily obtained.

AIR QUALITY MONITORING

The present air sampling network in the Baltimore area consists of samplers operated by the State of Maryland and the City of Baltimore. These samplers do not cover a large enough area or sample enough different pollutants to define the area's ambient air quality adequately. This is acknowledged by all of the cooperating health departments of the area. What is now needed is a comprehensive plan for an adequate sampling network.

Such a plan calling for the sampling of seven gaseous pollutants and three particulate pollutants and the recording of meteorological data at 17 stategically located primary stations has been proposed by the Baltimore Health Department.

Those pollutants known to be primary constituents of the air pollution in most communities are to be measured. The emission inventory proposed may point out other pollutants that should be measured. Nitrogen oxide, hydrocarbon, and total oxidant levels are important in photochemical smog formation. Concentrations of aldehydes are indicative of the reactive portion of hydrocarbon levels present. Carbon monoxide is primarily attributed to motor vehicle pollution. Sulfur dioxide is emitted from certain processes and fuel burning.

Definition of the levels of particulate of different characteristics is obtained from the three particulate pollutant measurements. The AISI sampler collects particles from 0.2 to 40 microns in size. Several studies have shown that the large particles collected do not appreciably affect percent transmission or reflectance readings. Therefore, the AISI sampler measures primarily 0.2- to 10-micron particles. Dustfall collectors gather only settleable particulate larger than 10 microns. The high-volume sampler collects particles from 0.03 to 100 microns in size.[10] Since the material collected by the high-volume sampler is quantitated on a weight basis, the results reflect primarily particulate greater than 10 microns.

The primary sampling station locations in the proposed comprehensive plan have been selected to be representative of the immediate area around Baltimore. Only one station, Owings Mills, lies well beyond the immediate metropolitan area. This station serves as a background station since it is far away from all major sources except Rosewood State Hospital. Winds from the southeast, which would bear pollution from the city to this station, occur less than 10 percent of the time (see Figure 20).

This plan's proposals have considerable merit, and we recommend their adoption with some alteration. The primary stations for this metropolitan Baltimore network have been well chosen, but the following improvements are recommended. Station 7 is located too far north. A site 2 miles to the southwest of the proposed one will show the transport of pollution from the bay area into the Dundalk residential area. Station 8 would be more valuable if placed in the more populated area of Essex. Station 13 should be placed in Ellicott City, if possible. The value of having a station at Friendship International Airport is debatable. This station would be better located at Linthicum near the high-density expressways. The 17-station network and these proposed improved sites are shown on Figure 23.

It is doubtful that all of the sampling equipment proposed for the stations will be useful. Some pollutant levels in some areas will seldom exceed background levels. It would be valueless to operate samplers at a location where the data produced can be expected to be a mass of zeroes. For this reason, discretion should be used in outfitting the sampling stations with sampling equipment. A complete station should be placed at site 12, however, since this is the background sampling station.

As an example, we may postulate that sulfur dioxide will be negligible at stations 2, 5, 9, 10, 11, 13, 14, 15, 16, and 17. This assumption may not be true, however, for all of these sites. Therefore, an initial check at each of these sites should be made by sampling during

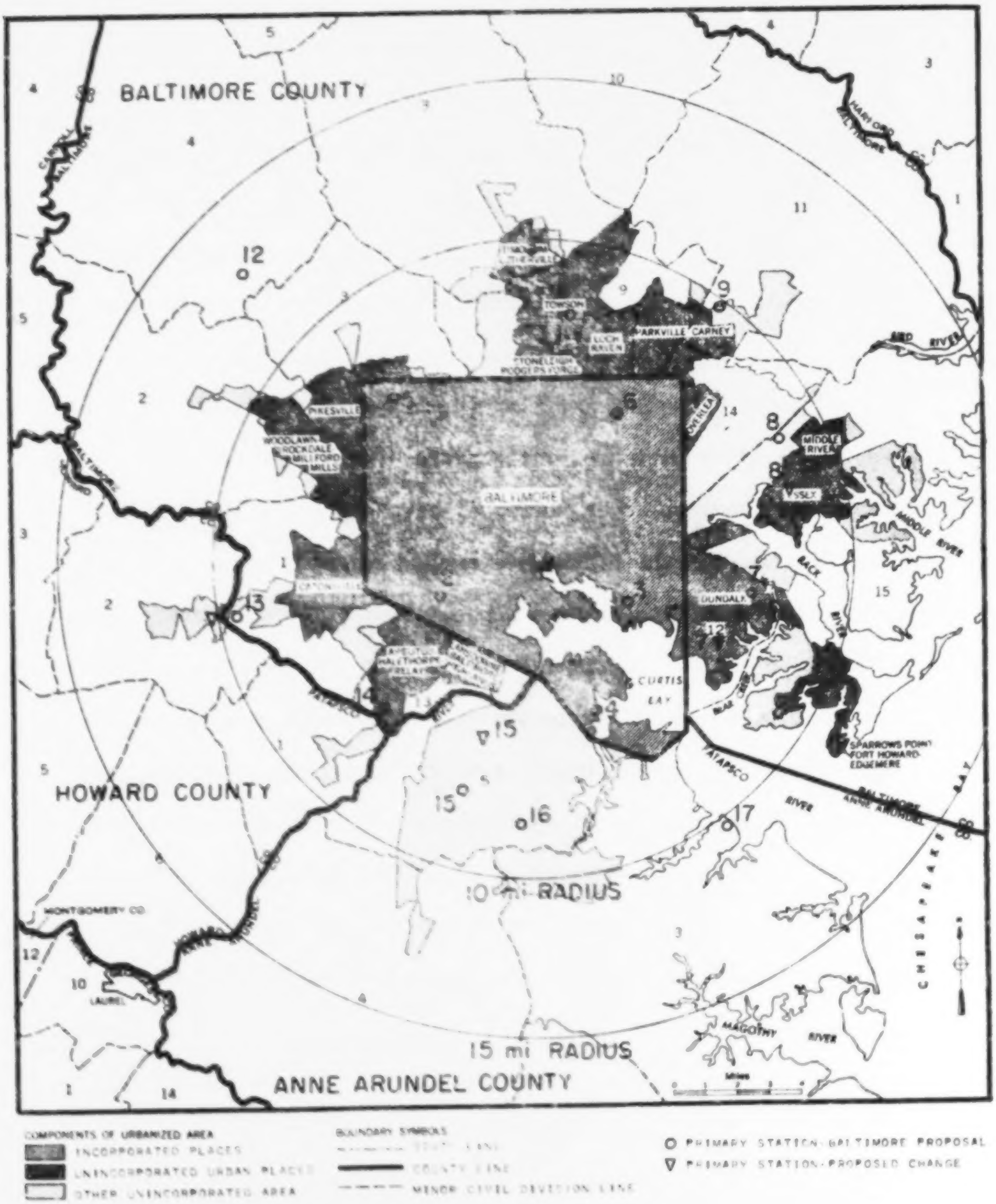


Figure 23. Primary station network.

a high-pollution-potential period. If levels of sulfur dioxide are found to exist at a site, then a sampler for this pollutant should be placed at the site. If negligible levels are found, then of course no sampler should be installed. A check of the site should be made, perhaps once a year, during a high-pollution period to determine whether the pollutant has begun to appear in quantity at the site. Such an approach will be considerably more economical than the establishment of completely equipped sampling stations at all of the strategic sites. Table 22 shows this approach applied to each of the proposed primary sampling sites.

To accomplish the pollutant sampling checks at the outlying sites, a mobile unit should be outfitted with complete sampling station equipment. Such a mobile unit would also be useful in checking a site's operation and evaluating problem areas not near a sampling site. Since travel distances are short and little travel would probably be done with such a unit, it should be built in a trailer with a self-contained power generator.

Care must be taken in the determination of sampling schedules. To keep the cost of the manual sampling program down and to prevent the loss of valuable man-hours, sampling schedules should be for only enough samples to give an adequate representation of the information desired. This means that decisions will have to be made on the number of samples to be taken per day for each pollutant, the time of sampling, the number to be taken per month or year, and other questions. Considerable savings can be realized if such decisions are made before the sampling program is begun. Of course, the sampling schedules must be flexible so that they allow for missed samples and changes based on new facts or circumstances.

Table 22. INITIAL EQUIPMENT NEEDS

Station	Location	NO_x	SO_2	Total Oxidant	CO CO_2	Hydro-carbons	Aliphatic aldehydes	Dust-fall	AISI	Hi-vol
1	Baltimore	yes	yes	yes	yes	yes	yes	yes	yes	yes
2	Baltimore	a	a	a	a	a	a	yes		yes
3	Baltimore	yes	yes	yes	yes	yes	yes	yes		yes
4	Baltimore	yes	yes	yes	yes	yes	yes	yes	yes	yes
5	Baltimore	a	a	a	a	a	a			yes
6	Baltimore	yes	yes	yes	yes	yes	a		yes	yes
7	Baltimore County	yes	yes	yes	yes	yes	yes		yes	yes
8	Baltimore County	yes	yes	yes	a	a	a	yes		yes
9	Baltimore County	a	a	a	a			yes		yes
10	Baltimore County	yes	a	yes	yes	yes	yes	yes	yes	yes
11	Baltimore County	yes	a	yes	a	a	a	yes		yes
12	Baltimore County	yes	yes	yes	yes	yes	yes	yes	yes	yes
13	Howard County	yes	a	yes	a	yes	a	yes	yes	yes
14	Baltimore County	a	a	yes	a	a	a			yes
15	Anne Arundel County	yes	a	yes	yes	yes	yes		yes	yes
16	Anne Arundel County	yes	a	yes	a	a	a	yes		yes
17	Anne Arundel County	a	a	yes	a	a	a	yes		yes
Mobile unit	Central office	yes	yes	yes	yes	yes	yes		yes	yes
Total equipment needs		13	8	15	9	10	8	12	9	18

[a] Check pollutant levels with the mobile unit.

Table 23. SATELLITE DUSTFALL STATIONS

Primary station	Satellite dustfall station	Primary station	Satellite dustfall station
1	1, 19, 20, 21, 22	9	satellite to 6
2	satellite to 1	10	10, 11, 45, 28, 29
3	3, 18	11	satellite to 10
4	17, 51, 36, 35, 4	12	12, 46, 30, 31, 47
5	satellite to 12	13	13, 48, 49, 2, 32
6	24, 9, 23, 25, 26, 27	14	satellite to 13
7	37, 38, 52, 39, 40, 41	15	16, 50, 34, 33
8	42, 44, 43, 8	16	satellite to 15
		17	satellite to 4

Sampling schedules can be varied considerably to give the same results. As an example, for a reliable estimate of a site's seasonal suspended particulate pollutant levels at least 25 samples are usually required per season. These 25 samples could be gathered in one, two, or more years, depending on the need for the estimate.

In the Baltimore proposal sampling equipment for nitrogen oxides is omitted. This evidently was an oversight since it is included in the Baltimore list of pollutants to be measured. Dustfall, with a few exceptions, should also be measured at the primary sites. The present dustfall sampling network operated by Baltimore should be expanded, as shown in Figure 24, to include the primary sampling sites plus additional sites. It is anticipated that such a large comprehensive network will require at least 10 sanitarians assigned to the most fully equipped stations to keep the equipment functional, to operate the equipment, and to gather the data produced. Partially equipped stations and dustfall stations may be satellite to fully equipped stations as indicated by Table 23.

SPECIAL STUDIES

Besides the ambient air sampling program and the emission inventory, several special studies should be carried out. These special studies include an odor survey, a corrosion study, an ambient air pollutant dispersal potential study, a human and animal health effects study, and a plant effects study.

Odor and particulate pollution generally produce more complaints than any other type of pollution. Particulate pollution is to be measured

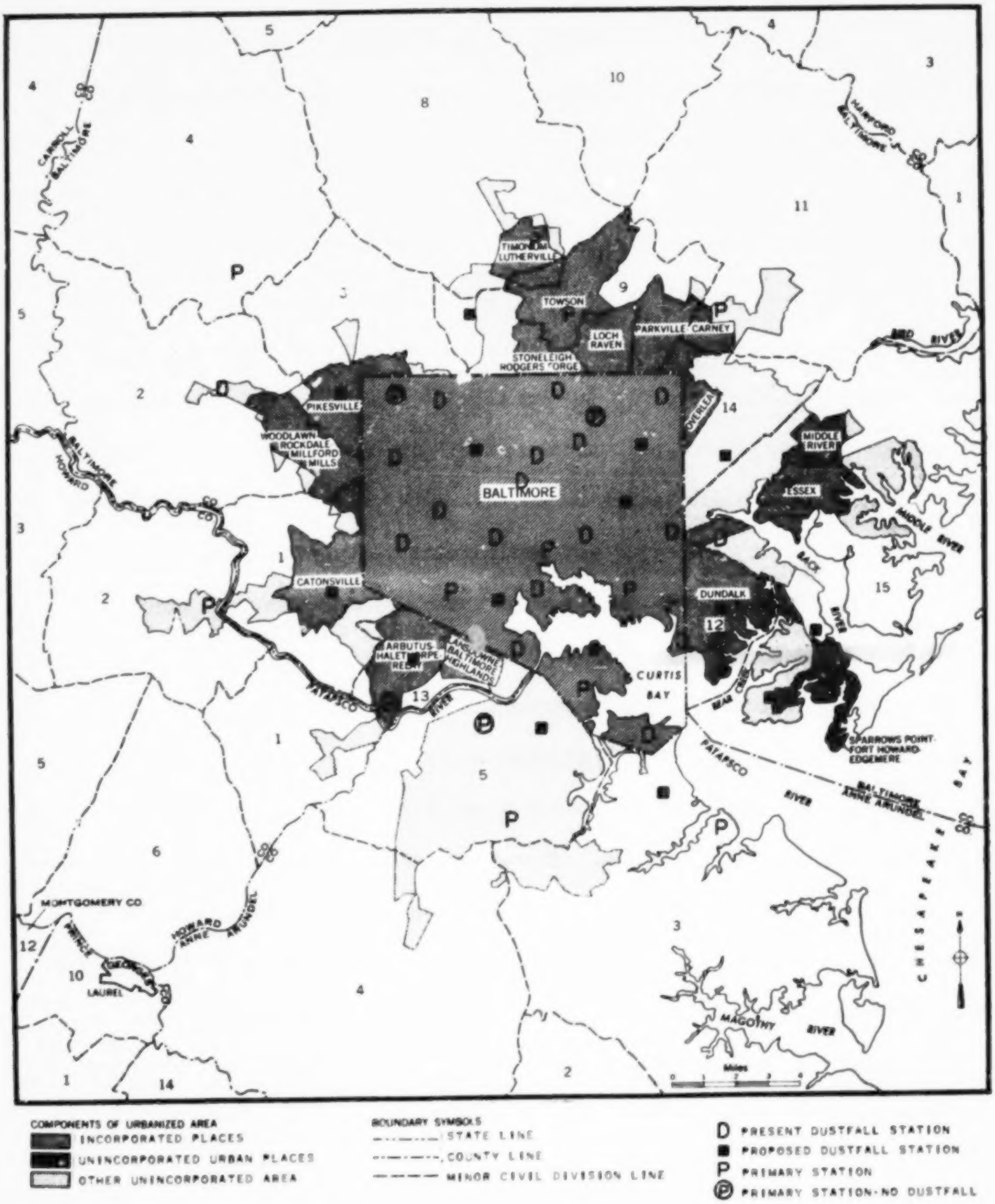


Figure 24. Proposed dustfall sampling network.

in the comprehensive study. Since no simple instruments are available by which odors can be measured, human observers must be used. For a good evaluation of the area's odor problem, a group of observers may be used to obtain information on the odors prevailing in different areas of the city at different times. The methods and organization for the conduct of odor surveys have been well defined in several studies (Lewiston-Clarkston, St. Louis, Kansas City) conducted by the Public Health Service.

Desired air quality levels must be based on the economic and health effects of air pollution as well as on aesthetic considerations. Unfortunately, little specific information is available on the economic and health effects of air pollution in the Baltimore area. A corrosion study would be a valuable addition to the sampling network. Such a study is inexpensive to organize, erect, and maintain. Dustfall stands are used to hold samplers that consist of a number of standardized steel plates exposed to the ambient air. This type of study is described in "Memorandum of Information and Instruction No. 3" from the St. Louis-East St. Louis Interstate Air Pollution Study, Public Health Service. Resources are not available for basic study work on human and animal health effects or plant effects. Therefore, the reports on these subjects will have to be limited to literature searches. Work is now being done under a Public Health Service grant on the effects of air pollution on the human respiratory system in Baltimore. The personnel directing this respiratory effects study may be available for consultative services on the human health effects study.

For the pollutant dispersal potential study, a meteorological consultant familiar with the Baltimore area should be retained to ascertain the ability of the air mass of the area to disperse pollutants under varying conditions. Meteorological data, emission inventory data, and air sampling data can be correlated to obtain valuable relationships between pollutant levels and meteorological variables. From these data and the correlations defined, a methodology for predicting future levels of air pollutants several hours or days before they occur should be developed and used. Such predictions could be used to direct control efforts to prevent any disastrous occurrences and to prevent excessive pollutant accumulation. A prediction service is a very important part of an air resource management program, not only for preventing air pollution disasters but also as an aid in making sound planning and zoning decisions related to both single and multiple air pollutant source configurations. In addition, the prediction methodology could be used to evaluate the effects that major pollution sources have on their surrounding areas. From effects so determined, needed controls could be derived.

ADMINISTRATION

Obviously, such a large sampling network requires centralization of authority under a project director. To accomplish centralization, a project agreement must be drawn up by the proposed regional committee, specifying the organization and duties of project personnel and the resources to be supplied by each cooperating agency. Personnel would have to be hired by the cooperating agencies and assigned to the project. A problem arises in that every person assigned to the project would have two bosses, his local superior and the regional air resource management committee. The fact that each local superior would be represented on the regional committee mitigates this problem and makes it entirely dependent upon the degree of cooperation between committee members.

At present, no strong air pollution control work has been done in the cooperating counties, and present personnel are not adequately trained in air pollution control work. Individuals hired and assigned by the counties to the survey project should also handle the counties' air pollution complaints on a first priority basis. It is anticipated that these personnel would then, on completion of the survey and adoption of air quality standards and air pollution control regulations by the counties, become the regulatory personnel for the county health departments.

The present programs administered by the State Department of Health and the City Health Department must, of course, continue to operate. Therefore, personnel from these agencies must be available to assist with control work and other projects under provisions that should be stated in the project agreement.

As now envisioned, sampling station personnel would be supplied by the local health departments and central office and laboratory personnel assigned by the State Department of Health. The duties of the technical personnel would include:

1. **Station sanitarians**: Investigate complaints occurring near the assigned station. Operate manual sampling equipment. Maintain station equipment. Check and tabulate raw data on data-processing forms. Help with any special surveys.

2. Principal chemists: Maintain automatic sampling equipment at each station.
3. Public health engineers: Investigate complaints. Collect emission inventory data and conduct source evaluations. Help with special surveys.
4. Central office senior public health engineer: Direct emission inventory and air sampling surveys. Coordinate all work done. Direct special surveys.
5. Central office public health engineer: Collate and analyze emission inventory and air sampling data. Work with public health engineers in obtaining data. Help with special surveys.
6. Central laboratory principal chemist, chemist, and electronic instrument technician: Aid chemists in maintaining automatic sampling equipment. Direct manual sampling. Prepare reagents for manual sampling. Maintain standards and standardize equipment. Operate the mobile laboratory.
7. Senior key-punch operator: Transmit data to data-processing cards.

FREQUENCY OF SAMPLING AND DURATION OF STUDY

The purpose of the comprehensive sampling program is to determine the ambient concentration levels of major pollutants throughout the metropolitan area and the effects of various parameters, such as season, time of day, wind direction, and wind speed, on these levels.

Previous studies have established that sampling continuously is not necessary to provide adequate descriptive data for certain pollutants. High-volume suspended particulate samplers can obtain statistically sound data for estimating seasonal and annual means if operated 100 to 130 days per year on an every-third-day schedule. Frequency of manual sampling for aliphatic aldehydes and oxidants should be determined by the project's principal chemist.

This comprehensive study should not go on indefinitely. If work is begun immediately on obtaining adequate appropriations, the sampling network may be in operation by mid-1966. Sampling, special studies, and the emission inventory should be continued until a complete 12 month record of data has been collected. Within a 2-year period, adequate comprehensive air pollutant data should have been taken, the emission inventory completed, and special studies completed. During and after these studies, the data would be tabulated, correlated, and used for making basic decisions in planning the air resource management plan for the metropolitan area.

Not all of the sampling stations should be closed at the end of the comprehensive study. Those stations most representative of maximum occurrences of pollutant levels could be maintained as an air monitoring network. The emission inventory should be kept up to date and improved after completion of the study. In any air resource management program, knowing what goes into the air is good business. This information should be required through the establishment of a permit or registration system for large sources by ordinance. The personnel released by the termination of study activities would be absorbed into the area's air pollution control programs, which will have grown with the recommended ordinances and control activities coming from the study.

SELECTION OF AMBIENT AIR QUALITY STANDARDS

The ultimate goal of any good air pollution control program is the establishment and maintenance of optimal use of the ambient air resource. To reach such a goal, optimal use must be defined. Certainly it cannot mean unrestricted use or the maintenance of pristine, pure air. Rather, a compromise between these two extremes is required. One of the purposes of the comprehensive survey is to obtain data for the derivation of this compromise. Figures for desired air quality must strike a balance between health effects, property damage, and aesthetic values and the economics of air pollution control. In addition, allowance must be made for future growth of the area's population and economy.

The desired air quality for different areas will be different. Industrial areas do not require the odor-free "clean" air so often demanded in residential areas. Even industrial areas vary in their need for clean air; some industries cannot tolerate heavily polluted air in their processes. This varied need and desire for clean air emphasizes the importance of planning and zoning agencies in air pollution control. Through the control of land use, certain degrees and types of air pollution can be restricted to specific areas.

DESIGN OF POLLUTANT EMISSION CONTROL REGULATIONS

Today the City of Baltimore has the only effective local control agency, enforcing emission control regulations, in the metropolitan area. Some of these regulations, having been modeled after ASME recommendations published in 1949, are out of date. These emission control regulations should be reviewed and revised in the light of emission inventory data, selected air quality standards, and the control performance now attained by major sources, not only in Baltimore, but also in the United States. Modern control requirements are found in New York City, Los Angeles, San Francisco Bay Area, and Detroit laws.

Modern pollutant emission control regulations should be included in ordinances produced for the county control agencies. Each ordinance must be molded to fit the control agency, control need, and control capability of each county. In some instances control ordinance provisions may be needed before completion of the study. In such cases the ordinances should be adopted as needed and then revised later in the light of the results of the comprehensive study.

TRAINING OF PERSONNEL

One of the most important accomplishments of the comprehensive study should be the training of a number of personnel to strengthen technical air pollution control staffs of the State and the City of Baltimore and to provide qualified staffs for county control programs.

Selected members of the comprehensive study staff should be sent to take air pollution courses offered by the Robert A. Taft Sanitary Engineering Center during the study.

With such training and the practical training received in executing duties associated with the comprehensive study, well-oriented individuals will be prepared to move into control activities of the local health departments. Especially valuable in the training of these individuals will be the work done in obtaining emission inventory data, complaint handling, the manipulation and maintenance of sampling equipment, and close association with specific problem areas.

PUBLIC INFORMATION

It is very important that the news media and, hence, the public be kept closely informed on meetings of the regional committee and important developments in the comprehensive study. Monthly or bimonthly progress reports to news media and political leaders should be required. Any special events such as project agreement signings, special hearings, or Cleaner Air Week should be widely publicized and made more interesting to all through the use of graphical presentations and exhibits. Short pamphlets outlining objectives, accomplishments, and the meaning of information gathered should be produced and distributed.

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